REPORT

FINAL REPORT

SNRB™ AIR TOXICS MONITORING

To

BABCOCK & WILCOX

January 1994

Battelle
. . . Putting Technology To Work

FINAL REPORT

on

SNRB™ AIR TOXICS MONITORING

to

BABCOCK & WILCOX

January 1994

Sponsored by

U.S. DEPARTMENT OF ENERGY
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THE OHIO DEPARTMENT OF DEVELOPMENT
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and
OHIO EDISON COMPANY

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) is collaborating with the Electric Power Research Institute (EPRI), the U.S. Environmental Protection Agency (EPA), and the Utility Air Regulatory Group (UARG) to develop a more complete data base for the emissions of hazardous air pollutants (HAPs or air toxics) from utility boilers. The DOE is also supporting the development and commercialization of a wide variety of power plant-related technologies under its Innovative Clean Coal Technology (CCT II) program. One of the CCT II technologies is Babcock & Wilcox's SOx-NOx-Rox (SNRB™) process. SNRB™ is a multiple pollutant emission control process which incorporates dry sorbent injection for SO_2 capture, selective catalytic reduction for NO_X reduction, and high-temperature fabric filtration for particulate matter control.

The objectives of the SNRB™ Air Toxics Monitoring Project were twofold: (1) to provide data on SNRB™ air toxics emissions control performance; and (2) to add to the DOE/EPRI/EPA/UARG data base of air toxic emissions from utility boilers. Funding for the project was provided by DOE, EPRI, Ohio Edison, and the Ohio Coal Development Office within the Ohio Department of Development.

The project involved measurement of a variety of toxic chemicals in solid and gaseous samples from input, output, and process streams of the SNRB™ process in a 5 MWe demonstration facility. The SNRB™ demonstration facility is located at Ohio Edison's R.E. Burger Plant near Shadyside, OH. Emissions from Boiler #8 at the Burger plant were also evaluated. Boiler #8 is a 160-MWe, pre-NSPS (new source performance standards), pulverized coal, wall-fired boiler. A Buell electrostatic precipitator (ESP) is installed for pollution control.

Sampling was conducted at the Burger plant from April 26 to May 2, 1993. A blend of medium sulfur, bituminous Ohio coals from a single supplier was fired during the sampling period. Ohio Edison provided reproducible conditions for sampling by maintaining Boiler #8 at full load and steady operating conditions. Samples were collected from the following process streams:

Coal Feed	SNRB™ Inlet
Sorbent Feed	Baghouse Inlet
SNRB™ Solids	SNRB™ Outlet
Bottom Ash	Economizer Ash
ESP Inlet	ESP Ash
ESP Outlet	

Samples were analyzed for the following air toxics:

Trace Elements	Chloride/Fluoride
Carbonyls	Polynuclear Aromatic Hydrocarbons (PAH)
Dioxins/Furans	Volatile Organic Compounds
Radionuclides	

Particulate loading was also measured. The resulting data were used to determine emission factors, removal efficiencies for the ESP and SNRB™, and material balances for trace elements across the boiler, ESP, and SNRB™.

A summary of key data for the ESP and SNRB™ is provided in Tables 1 and 2, respectively. Included in these tables is the outlet concentrations, or emission factors, removal efficiencies, and material balance closures achieved for particulate matter, trace elements, chloride, and fluoride. As shown, the reported removal efficiency for the ESP was greater than 99 percent for all compounds except mercury, manganese, selenium, chloride, and fluoride. For the SNRB™, greater than 99 percent removal efficiency was achieved for all compounds except mercury, cadmium, nickel, and antimony. The high material balance closures for the ESP are thought to be the result of a low bias in the measurement of particulate-phase metals for the boiler outlet (ESP inlet). This bias also affected material balance closures for the boiler which were generally less than 100 percent. The cause of this low bias is suspected to be less than ideal sampling conditions.

Organic air toxics, including volatile organic compounds, PAH, dioxins/furans, and carbonyls were analyzed in gaseous emission streams only. For volatile organic compounds, ESP and SNRB™ emissions were generally in the range of 1 to 20 lb/10^{12} BTU. Of the 26 volatile organic compounds for which results are reported, only 12 were detected in ESP and SNRB™ emissions. ESP and SNRB™ emissions factors for PAH were generally in the range of 0.002 to 0.1 lb/10^{12} BTU. Dioxins/furans were detected in SNRB™ and ESP emissions in the concentration range of approximately 0.000002 to 0.00001 lb/10^{12} BTU. The isomer 2,3,7,8-tetrachlorinated dibenzofuran was detected in most of the gaseous process streams. Carbonyl emissions were not detected in any of the gaseous process streams. A high particulate loading in gas samples collected with an EPA Method 23 train for PAH and dioxin/furan analysis appeared to interfere with efficient sample extraction. Consequently, PAH and dioxin/furan spike recoveries for samples with high particulate loading were lower than expected. Analysis of carbonyls in gas samples collected with a Method 0011 train may have been affected by the use of incompatible solvents for sample collection and recovery. However, additional analyses conducted to evaluate the separate solvents did not confirm this problem. No other significant deviations or adverse quality assurance/quality control results were noted for either sampling or analysis activities.

TABLE 1. SUMMARY OF KEY DATA FOR ESP

Substance	Outlet Concentration ($lb/10^{12}$ BTU)	Removal Efficiency (%)	Material Balance Closure[a] (%)
Particulate Matter	0.045[b]	99.29	NC[c]
Mercury	8.77	-27	165
Chromium	0.91	99.67	122
Cadmium	6.6#[d]	100	108
Nickel	7.9#	99.94	116
Barium	5.4#	99.83	200
Cobalt	7.9#	100	100
Manganese	10.25	95.05	123
Vanadium	3.4#	99.82	126
Beryllium	6.6#	100	113
Arsenic	2.93	98.98	316
Lead	0.09#	99.95	136
Antimony	0.08	99.09	153
Selenium	30	74.43	98
Chloride	32,334	-5.5	NC
Fluoride	5,488	-28	NC

a. Data screened for outliers.
b. Results in $lb/10^6$ BTU.
c. NC = Not calculated.
d. # indicates average emission factor calculated from one or more non-detect values.

TABLE 2. SUMMARY OF KEY DATA FOR SNRB™

Substance	Outlet Concentration (lb/10^{12} BTU)	Removal Efficiency (%)	Material Balance Closure[a] (%)
Particulate Matter	0.027[b]	99.57	NC[c]
Mercury	12.5	-78	155
Chromium	7.6#(d)	98.4	101
Cadmium	3.0#	66.2	34
Nickel	34#	75.1	84
Barium	5.1#	99.98	19
Cobalt	6.9#	97.5	106
Manganese	3.0#	99.77	104
Vanadium	8.1#	100	121
Beryllium	7.6#	100	73
Arsenic	1.2	99.53	556
Lead	0.51#	99.51	77
Antimony	0.78	89.8	66
Selenium	0.10#	100	138
Chloride	470	99.99	NC
Fluoride	37#	99.14	NC

a. Data screened for outliers.
b. Results in lb/10^6 BTU.
c. NC = Not calculated.
d. # indicates average emission factor calculated from one or more non-detect values.

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I. INTRODUCTION

A. Rationale for the Project

The U.S. Department of Energy (DOE) is collaborating with the Electric Power Research Institute (EPRI), the U.S. Environmental Protection Agency (EPA), and the Utility Air Regulatory Group (UARG) to develop a more complete data base for the emissions of hazardous air pollutants (HAPs or air toxics) from utility boilers. The Clean Air Act Amendments of 1990 identified 189 such substances, and charged the EPA with determining the need for emissions control regulations for each substance. The air toxics data base will be used by the EPA, in conjunction with the results of studies of the impacts of these emissions on public health, to promulgate air toxics emissions control regulations, as required. Development work on the data base is being supported by DOE's Pittsburgh Energy Technology Center, Office of Project Management, and by EPRI under its Power Plant Integrated Systems: Chemical Emissions Study (PISCES) project.

The DOE is also supporting the development and commercialization of a wide variety of power plant-related technologies under its Clean Coal Technology (CCT II) Program. These projects are aimed at the environmentally-sound use of coal. As such, environmental monitoring is an important aspect of each project -- both to demonstrate compliance with project operating permits (compliance monitoring), and to evaluate the potential environmental performance and impacts of the subject technology (supplemental monitoring). In keeping with this philosophy the DOE has issued guidelines for extending the supplemental environmental monitoring being conducted under some of the clean coal projects to include the monitoring of air toxics. This is to be accomplished through the development and implementation of a site-specific air toxics monitoring plan for each applicable CCT II project.

B. Objectives of SNRB™ Air Toxics Monitoring

Babcock & Wilcox (B&W) is currently conducting a project under the DOE's CCT II Program to demonstrate its SO_x-NO_x-Rox Box™ (SNRB™) process in a 5 MWe Field Demonstration Unit at Ohio Edison's R. E. Burger Plant near Shadyside, Ohio. The objective of the SNRB™ Air Toxics Monitoring Project was to provide data on SNRB™ air toxics emissions control performance to B&W and to add to the DOE/EPRI/EPA data base by quantifying the flow rates of selected hazardous substances (or air toxics) in all of the major input and output streams of the SNRB™ process as well as the power plant. Work under the project included the collection and analysis of representative samples of all major input and output streams of the SNRB™ demonstration unit and the power plant, and the subsequent laboratory analysis of these samples to determine the partitioning of the hazardous substances between the various process streams. The substances of interest are a subset of the 189 substances identified in the 1990 Clean Air Act Amendments, and include trace metal, volatile and semivolatile organic, carbonyl, acid gas, and radionuclide species. Material balances for selected air toxics were subsequently calculated around the SNRB™ and host boiler systems, including the removal efficiencies across each of the major air pollution control devices. A matrix of the process streams that were characterized and the parameters determined in the SNRB™ Air Toxics Monitoring Project is presented in Table I-1.

C. Organizations Involved

The overall organization of the SNRB™ Air Toxics Monitoring Project is illustrated in Figure I-1. The primary organizations involved in conducting this project were:

- Babcock and Wilcox (B&W)
- Ohio Edison
- Battelle
- Energy and Environmental Research Corporation (EER)
- Frontier Geosciences.

In summary, B&W had overall responsibility for the SNRB™ demonstration project under DOE's CCT II Program. B&W was responsible for operating and monitoring the SNRB™ system. Ohio Edison provided the host site for B&W's CCT II demonstration project and was responsible for site preparation activities. Battelle was responsible for the entire air toxics monitoring project including planning, testing, analyzing, and final reporting. EER was a major subcontractor to Battelle and had responsibility for collecting samples, reducing data, and reporting on sampling. Frontier Geosciences conducted an independent characterization of mercury emissions under the direction of B&W.

D. Description of the Report

This report presents results of the SNRB™ Air Toxics Monitoring Project. In addition to the Introduction, a brief description of the test site, including the Boiler No. 8 and the SNRB™ process, is included in Section II. The concentrations of air toxic emissions are presented in Section III according to compound class. Material balances are included in Section IV for three major systems: boiler, electrostatic precipitator (ESP), and SNRB™. Emission factors and removal efficiencies are also presented according to compound class in Sections V and VI, respectively. A data evaluation is provided in Section VII. This evaluation describes deviations from planned procedures and operations for the boiler and SNRB™ process operation, field sampling, and laboratory analyses. The impact of these deviations on emission data is also discussed. Appendix A provides a separate report on speciated mercury measurements conducted by Frontier Geosciences.

TABLE I-1. TESTING MATRIX FOR SNRB™ AIR TOXICS MONITORING PROJECT

Parameter to be Determined[b]	Flue Gas or Process Streams Characterized											
	Coal Feed	SNRB™ Inlet[a]	Sorbent Feed	Ammonia Feed	Baghouse Inlet[a]	SNRB™ Solids	SNRB™ Outlet[a]	Bottom Ash	Economizer Ash	ESP Inlet[a]	Collected Flyash	ESP Outlet[a]
Mass Flow Rate[c]	X	X	X	X	X	X	X	X	X	X	X	X
Higher Heat Value	X											
Proximate Analysis	X											
Ultimate Analysis	X											
Unburned Carbon						X		X	X		X	
Trace Elements[d]												
Total	X	X	X		X	X	X	X	X	X	X	X
Vapor Phase		X			X		X			X		X
Solid Phase		X			X		X			X		X
Particulate Loading		X			X		X			X		X
Particulate Sizing					X		X			X		X
Volatile Organics		X			X		X			X		X
PAH[e]		X			X		X			X		X
Dioxins/furans					X		X			X		X
Carbonyls		X			X		X			X		X
Acid Gases		X			X		X			X		X
Chloride/fluoride	X		X			X		X	X		X	
Radionuclides	X				X		X			X		X
Loss on Ignition						X		X	X		X	
Mercury Speciation[f]							X					X

(a) Flue gas streams.
(b) Material balances were calculated for systems as indicated in Section IV.
(c) Mass flow rates were either measured or estimated; see Section IV.
(d) Trace elements include As, Ba, Be, Cd, Co, Cr, Hg, Mn, Ni, Pb, Sb, Se, and V.
(e) PAH = Polynuclear aromatic hydrocarbons.
(f) Mercury speciation was conducted by Frontier Geosciences Environmental Research Corporation (Seattle, WA) as a separate project and is only indicated here to acknowledge that this work was conducted simultaneously with the SNRB™ Air Toxics Monitoring project.

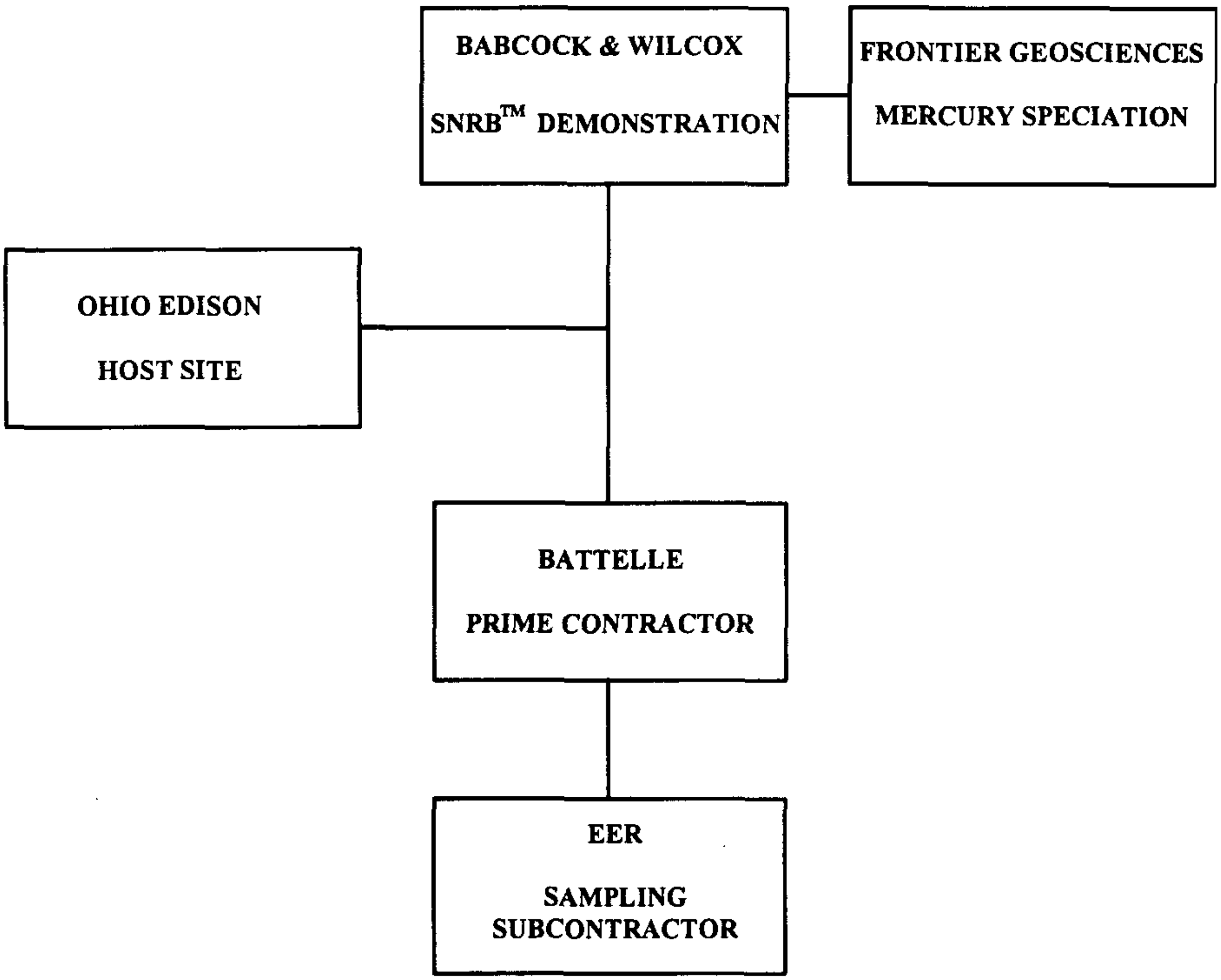


Figure I-1. Organizations Involved in SNRB™ Air Toxics Monitoring Project

II. SITE DESCRIPTION

A. Boiler No. 8

Boiler No. 8 at Ohio Edison's R. E. Burger Plant located near Shadyside, Ohio is a 160-MWe, pre-NSPS (new source performance standards), pulverized coal, wall-fired boiler. The unit had been out-of-service for 3 months preceding the air toxics testing to repair the turbine shaft. The Buell ESP was installed in 1982. A blend of medium sulfur, bituminous Ohio coals from a single supplier was fired during the air toxics monitoring project. Expected operating conditions for Boiler No. 8 and the ESP are presented in Table II-1. Allowable ranges are also shown. When the values of operating parameters were within these allowable ranges, the testing was allowed to proceed.

B. SNRB™ Process

The SNRB™ process -- see Figure II-1 -- comprises the injection of both ammonia and dry sorbent upstream of a fabric filter (baghouse). A catalyst for the selective catalytic reduction (SCR) of nitrogen oxides (NO_x) is mounted inside the filter bags, providing for the destruction of NO_x as the flue gas/ammonia mixture passes over the catalyst. Sulfur oxides (SO_x) are absorbed by the sorbent both in the flue gas duct, and on the filter bags in the baghouse. Because the SO_x and NO_x removal processes require operation at elevated gas temperature (450-900°F), special high-temperature fabric filter bags are used.

The SNRB™ demonstration facility draws a 5 MWe (equivalent) flue gas slip stream from Boiler No. 8. The SNRB™ baghouse consists of six individual modules each containing 42 bag/catalyst assemblies. It is designed to handle about 30,000 ft^3/min (actual) of flue gas. Other major features include:

- A Bailey Network 90 system for integrated process control
- An automated ammonia injection system

TABLE II-1. BOILER NO. 8 EXPECTED OPERATING CONDITIONS

Parameter	Expected Value	Allowable Range
Load, MW	150 - 156	135 - 158
Oxygen monitor readings, percent	3.0 - 5.0	2.9 - 5.3
Steam temperature at superheater outlet, F	1,050	1,000 - 1,060
Steam temperature at reheater outlet, F	1,000	950 - 1,010
Steam pressure, psig	2,050	2,000 - 2,075
Steam generation rate, lb/hr	1,100,000	$0.95 - 1.2 \times 10^6$
Stack opacity, percent	5 - 10	≤ 15
Stack SO_2 (measured at SNRB™ inlet), ppm	2,100 - 2,500	Actual
Stack NO_x (measured at SNRB™ inlet), ppm	400 - 500	Actual

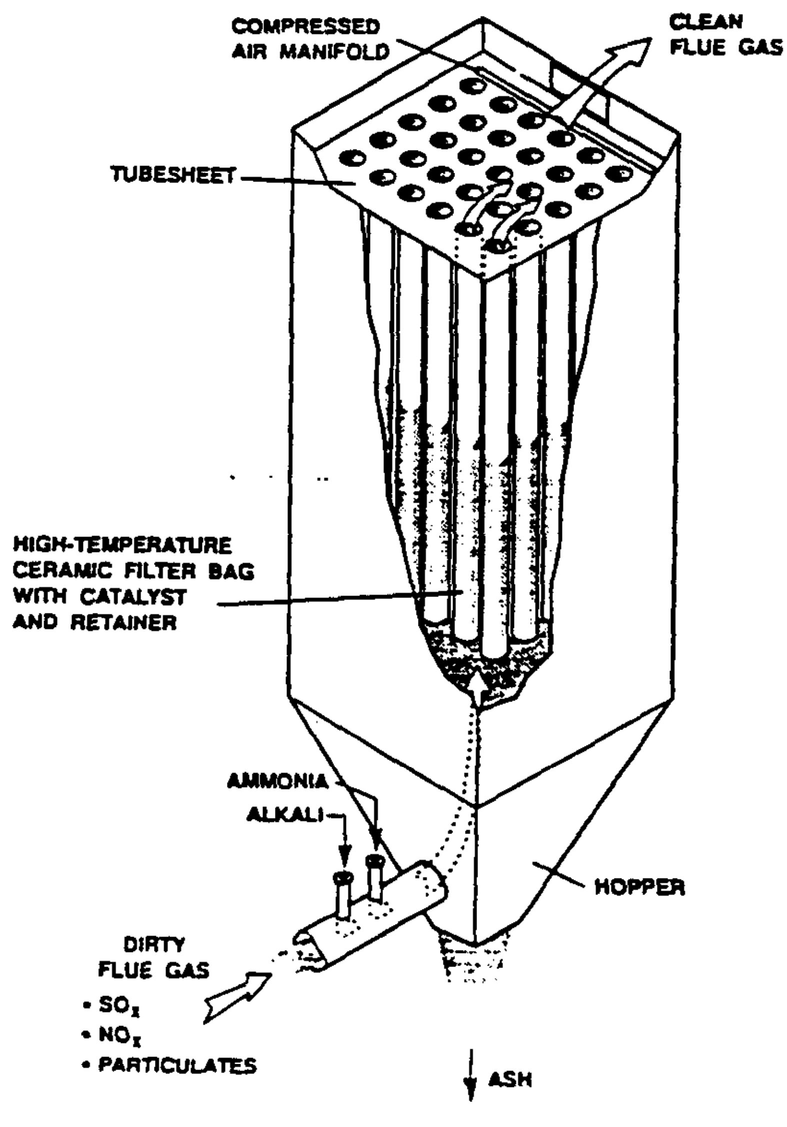


Figure II-1. SO_x-NO_x-Rox Box Process Schematic

- Automated sorbent feed and ash disposal systems

- Five sorbent injection locations (typically operating one at a time)

- A propane-fired heater for accurate control of the sorbent injection temperature

- Baghouse inlet and outlet flue gas heat exchangers to simulate the economizer and air heater sections of a host boiler, respectively.

The expected and allowable operating conditions for the SNRB™ process are listed in Table II-2.

C. Sampling Locations

Emissions were characterized from the following process streams associated with Boiler No. 8 and the SNRB™ process:

Sampling Location Number	Process Stream	Type of Stream
Location 1	Coal Feed	Solid
Location 2	SNRB™ Inlet	Gas
Location 3	Sorbent Feed	Solid
Location 4*	Ammonia Feed	Gas
Location 5	Baghouse Inlet	Gas
Location 6	SNRB™ Solids	Solid
Location 7	SNRB™ Outlet	Gas
Location 8	Bottom Ash	Solid
Location 9	Economizer Ash	Solid
Location 10	ESP Inlet	Gas
Location 11	ESP Ash	Solid
Location 12	ESP Outlet	Gas

* Samples not collected from this location for laboratory analysis.

TABLE II-2. SNRB™ EXPECTED OPERATING CONDITIONS

Parameter	Expected Value
Modules on line	5
Inlet SO_2 concentration, ppm	1,950 - 2,550
Inlet NO_x concentration, ppm	350 - 500
Sorbent feed rate, lb/hr	450 - 500
Ammonia injection rate, lb/hr	7.0 - 8.0
Ammonia atom.-air injection rate, lb/hr	200 - 225
Baghouse pressure drop, in. water	10 - 14
Outlet SO_2 concentration, ppm	350 - 1,400
Outlet NO_x concentration, ppm	30 - 250
Outlet duct opacity, percent	<10

A schematic diagram illustrating the location of these process streams is provided in Figure II-2. The gas flow rates measured at the flue gas sampling locations during the study are provided in Table II-3.

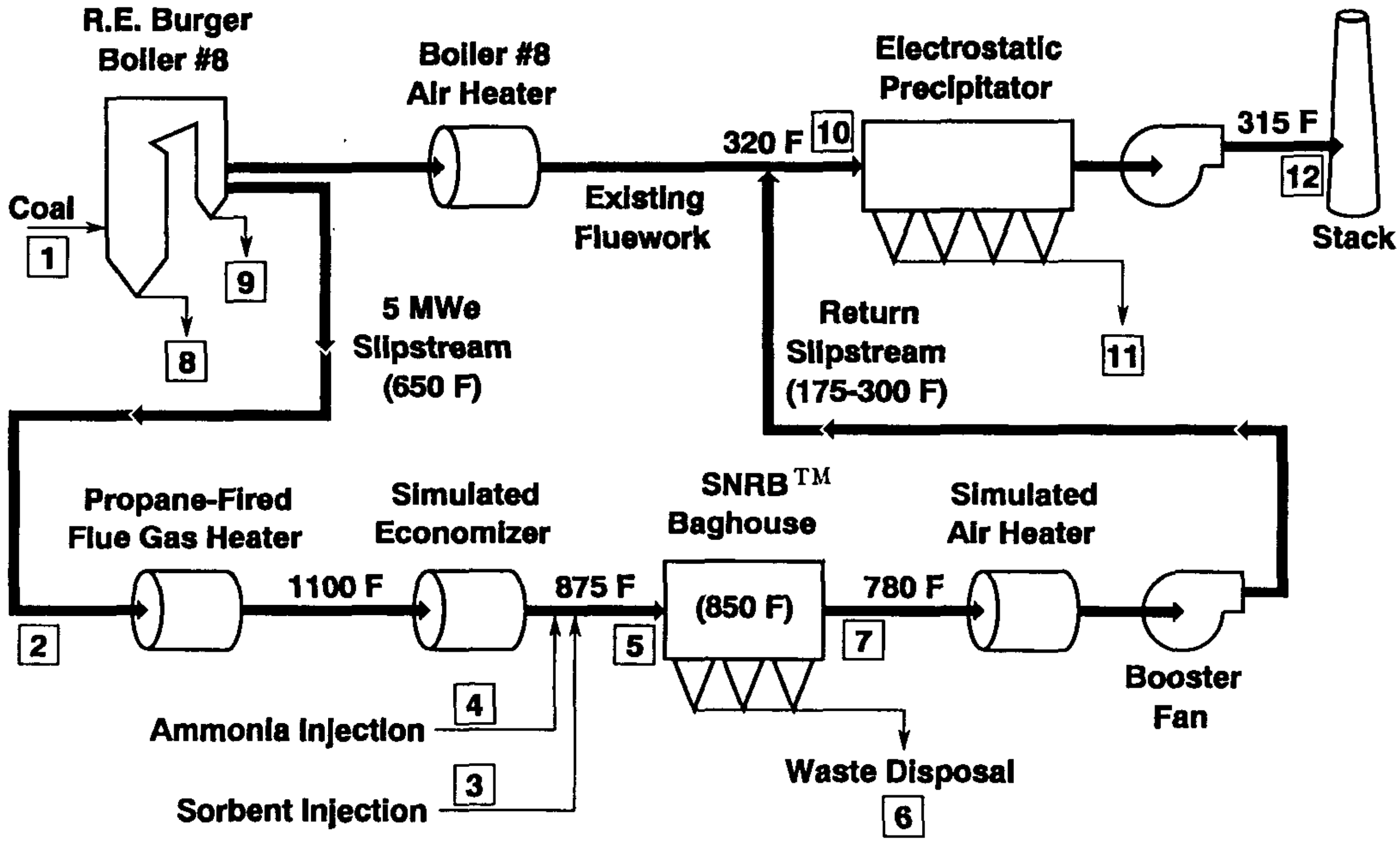


Figure II-2. Sampling Locations

TABLE II-3. FLUE GAS FLOW RATES[d]

Date	Flow Rate (dscf/min)				
	SNRB™ Inlet (Location 2)	Baghouse Inlet (Location 5)	SNRB™ Outlet (Location 7)	ESP Inlet (Location 10)	ESP Outlet (Location 12)
4/26/93	7,351[a]	8,342[b]	9,809[a]	345,186[a]	377,102[a]
4/27/93	7,545[c]	8,200[c]	9,515[c]	341,246[c]	374,433[c]
4/29/93	7,852[c]	8,870[c]	9,815[c]	346,208[c]	373,892[c]
4/30/93	8,004[c]	9,869[c]	10,069[c]	341,152[c]	375,306[c]
5/1/93	7,045[a]	8,753[b]	12,278[a]	331,583[a]	373,826[a]
5/2/93	7,414[a]	8,770[b]	9,649[a]	355,630[a]	376,495[a]

(a) From Method 26A train.
(b) From Method 5 train.
(c) From Method 29 Multi-Metals train.
(d) Flow rate, velocity, and moisture summaries for all trains are presented in Appendix F.

III. RESULTS

Results from the air toxics characterization are presented in this section separately for each compound class in the following order:

Particulate Loading
Particulate Size Distribution
Ultimate/Proximate, Loss on Ignition, and Unburned Carbon
Trace Elements
Chloride/Fluoride
Polynuclear Aromatic Hydrocarbons
Dioxins/Furans
Carbonyls
Volatile Organic Compounds
Radionuclides

Where appropriate, results for gaseous emissions are presented separately from results for the solid process streams within the compound classes. For ease in data presentation in most cases, samples are identified by a four-digit abbreviation signifying the associated run number and sampling location (i.e., R2-L7 which signifies the sample collected in Run 2 at Location 7). A brief comment on any trends in the data and any unusual results is also provided along with a discussion of how the data were treated.

A. Sampling Schedule

A summary of the sampling schedule completed for the SNRB™ Air Toxics Monitoring project is presented in Figure III-1. The sampling plan called for collecting three sets of data with each data set to be collected over a 2-day period. Each 2-day period was planned to be comprised of a day of inorganic sampling and a day of organic sampling. Collected gas sample volumes are listed in Table III-1. The standard temperature condition for determining dry standard cubic foot (dscf) and dry standard cubic meter (dscm) was 0°C (68°F).

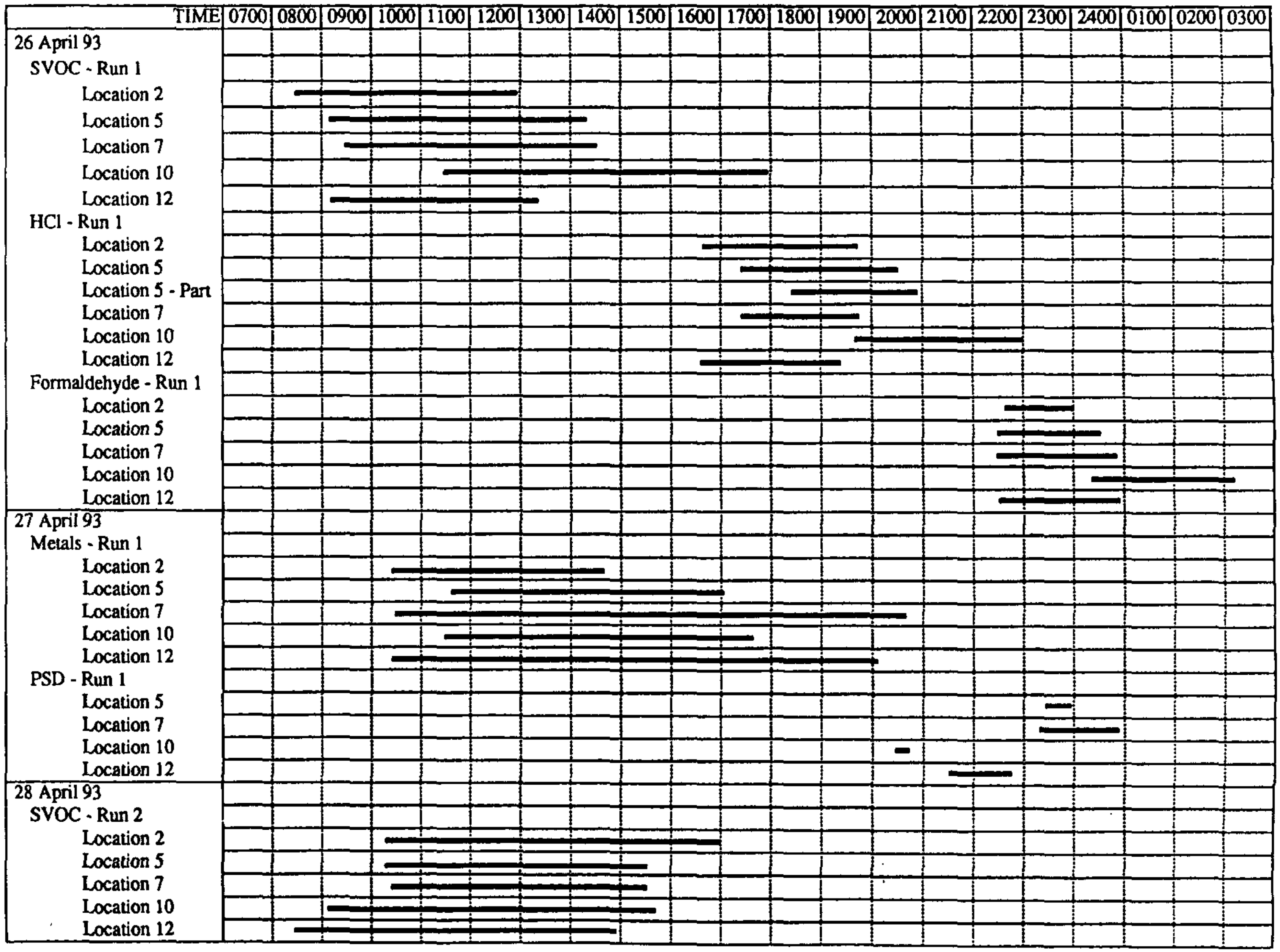


FIGURE III-1. TEST SCHEDULE SUMMARY

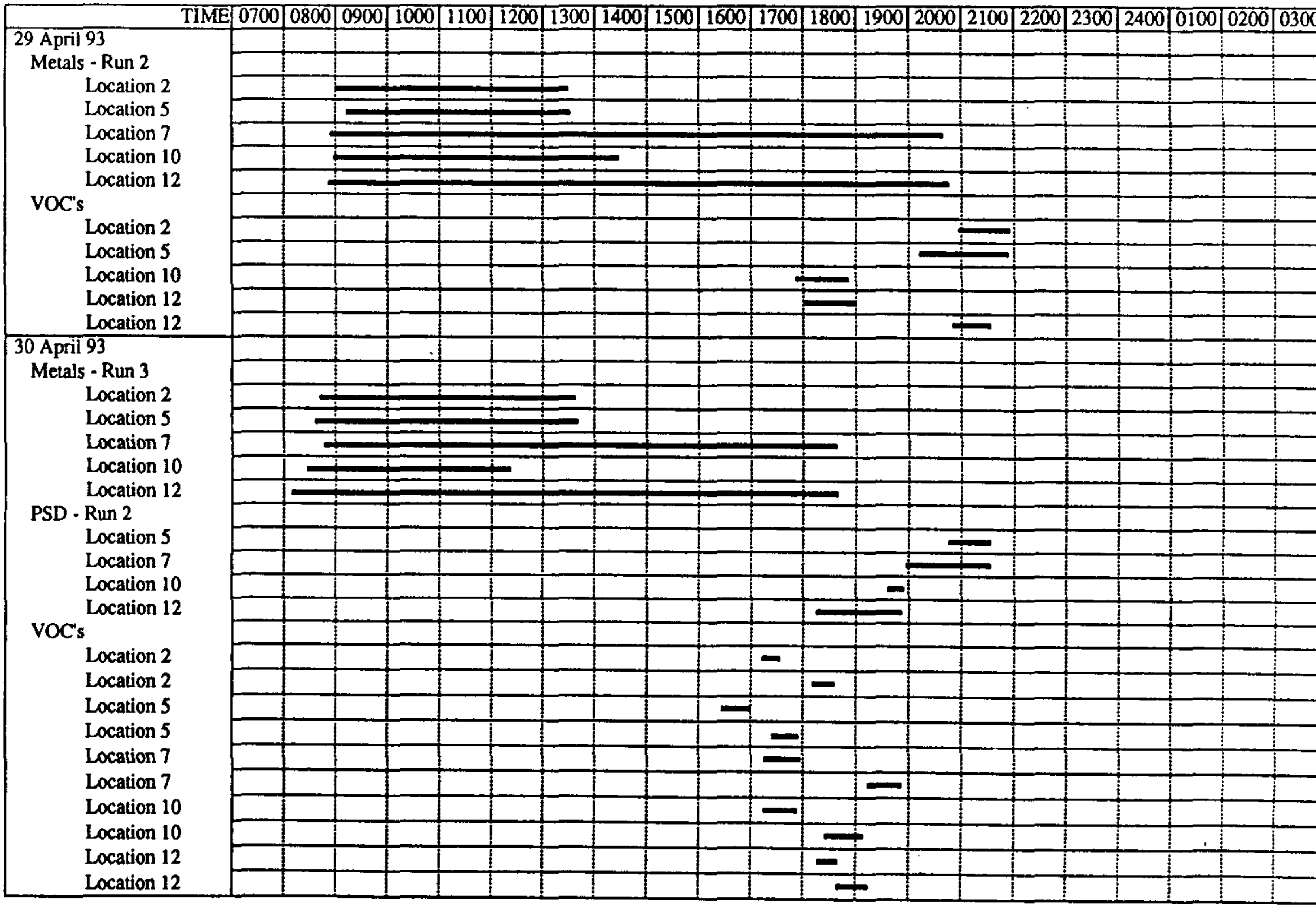


FIGURE III-1. TEST SCHEDULE SUMMARY (Continued)

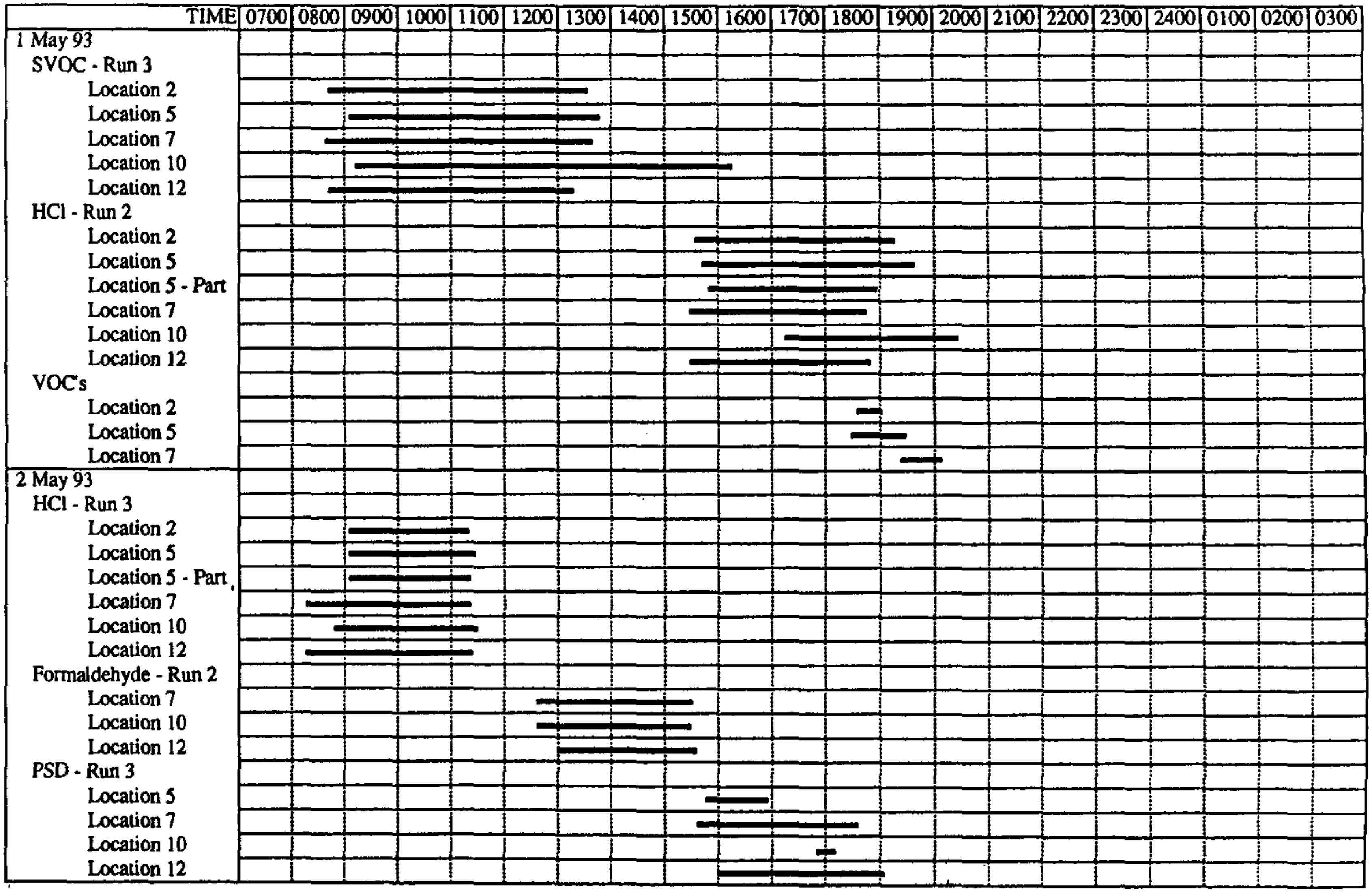


FIGURE III-1. TEST SCHEDULE SUMMARY (Continued)

TABLE III-1 . COLLECTED FLUE GAS SAMPLE VOLUMES

Sample Train	Test Date	SNRB™ INLET Location 2 (dscf)	(dscm)	BAGHOUSE INLET Location 5 (dscf)	(dscm)	SNRB™ OUTLET Location 7 (dscf)	(dscm)	ESP INLET Location 10 (dscf)	(dscm)	ESP OUTLET Location 12 (dscf)	(dscm)
SVOC-1*	26-Apr-93	114.88	3.25	126.85	3.59	139.47	3.95	107.06	3.03	114.09	3.23
SVOC-2	28-Apr-93	68.03	1.93	62.75	1.78	69.62	1.97	92.21	2.61	115.77	3.28
SVOC-3	1-May-93	96.79	2.74	128.84	3.65	155.93	4.42	125.95	3.57	112.13	3.18
Metals-1*	27-Apr-93	59.62	1.69	48.54	1.37	290.74	8.23	101.11	2.86	275.77	7.81
Metals-2	29-Apr-93	79.49	2.25	67.68	1.92	285.26	8.08	68.84	1.95	284.54	8.06
Metals-3	30-Apr-93	78.99	2.24	77.84	2.20	297.48	8.42	58.98	1.67	286.66	8.12
HCl/PART-1*	26-Apr-93	80.65	2.28	74.69	2.11	74.36	2.11	57.82	1.64	104.66	2.96
HCl/PART-2	1-May-93	82.36	2.33	62.25	1.76	78.91	2.23	64.18	1.82	105.18	2.98
HCl/PART-3	2-May-93	72.81	2.06	112.56	3.19	72.8	2.06	58.01	1.64	101.13	2.86
PART-1	26-Apr-93	--	--	64.47	1.83	--	--	--	--	--	--
PART-2	1-May-03	--	--	64.79	1.83	--	--	--	--	--	--
PART-3	2-May-93	--	--	62.03	1.76	--	--	--	--	--	--
Formaldehyde-1	26-Apr-93	83.57	2.37	66.67	1.89	70.56	2.00	63.54	1.80	107.02	3.03
Formaldehyde-2	2-May-93	--	--	--	--	74.23	2.10	65.42	1.85	100.7	2.85

*SVOC = Method 23 train for dioxins and PAH.
Metals = Method 29 multi-metals train for elements.
HCl/PART = *Method 26A train for HCl/F*, radionuclides, and particulate loading.
PART = Method 5 train for particulate loading at Location 5 only.
Formaldehyde = Method 0011 train for carbonyls.
dscm = Dry standard cubic meter.
dscf = Dry standard cubic foot.

B. Particulate Loading

Particulate loading of flue gas emissions, determined from particulate catch associated with the Method 26A samples (except for Location 5), are presented in Table III-2. An individual Method 5 train was run separate from the Method 26A train at Location 5 to determine particulate loading. The particulate loading data were treated as follows:

- Results were not corrected for the train blanks that were generated at Locations 7 and 12.
- Results were corrected for reagent blanks (probe rinse) in accordance with Method 5 procedures.
- As flagged, a negative weight was obtained for filters associated with three of the samples. These filters appeared to have a ragged edge upon receipt and some tearing may have occurred in the field. The particulate weight associated with these three filters was set at 0 mg in calculating the total particulate loading for the sample.

As expected, particulate loading at the inlet locations (Location 2 - SNRB™ Inlet, Location 5 - Baghouse Inlet, and Location 10 - ESP Inlet) is higher than particulate loading at the outlet locations (Location 7 - SNRB™ Outlet and Location 12 - ESP Outlet). Results for triplicate runs at individual locations are consistent within a factor of two.

C. Particulate Size Distribution

Sampling to determine particulate size distribution was conducted at Location 5 (Baghouse Inlet) and Location 10 (ESP Inlet) with a Mark V five-stage series cyclone, and at Location 7 (SNRB™ Outlet) and Location 12 (ESP Outlet) with Andersen cascade impactors. Triplicate runs were conducted at each location. Results from the particulate size distribution are presented in Figure III-2 for Location 5; Figure III-3 for Location 7; Figure III-4 for Location 10; and Figure III-5 for Location 12. Results are also presented in Tables III-3 to III-14.

TABLE III-2. PARTICULATE LOADING**

Location	Sample	Gas Volume (dscm)	Total Particulate (g)	Particulate Loading (mg/dscm)	
Location 2 - SNRB Inlet	R1-L2	2.28	16.4	7180	
	R2-L2	2.33	18.2	7810	
	R3-L2	2.06	21.6	10500	
Location 5 - Baghouse Inlet	R1-L5	2.11	40.6	19200	
	R2-L5	1.76	44.8	25500	
	R3-L5	3.19	47.1	14800	
Location 7 - SNRB Outlet	R1-L7	2.11	0.0792	38	
	R2-L7	2.23	0.0613	27	*
	R3-L7	2.06	0.0413	20	
	Blank	2.10	0.0075	4	*
Location 10 - ESP Inlet	R1-L10	1.64	15.9	9680	
	R2-L10	1.82	14.8	8150	
	R3-L10	1.64	15.0	9120	
Location 12 - ESP Outlet	R1-L12	2.96	0.1600	54	
	R2-L12	2.98	0.1890	64	
	R3-L12	2.86	0.1080	38	
	Blank	2.90	0.0016	1	*

*Negative weight obtained for filter possibly due to tearing of filter in field; filter weight assumed to be 0 in adding acetone rinse and filter particulate catch.
**Results are reported using three significant figures only.
(QPro Filename: PRESENT2.WB1)

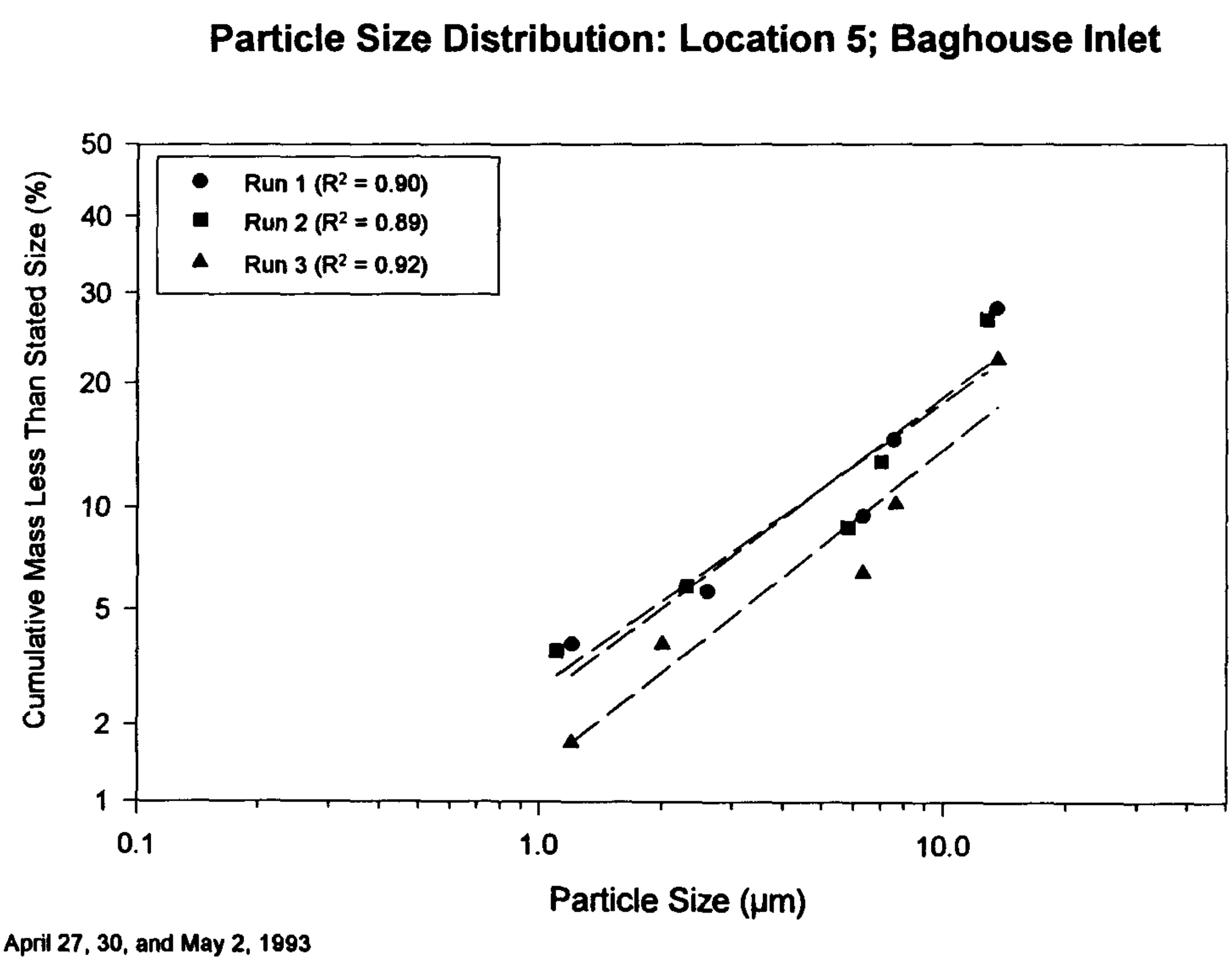


Figure III-2. Particle Size Distribution Measured at Location 5

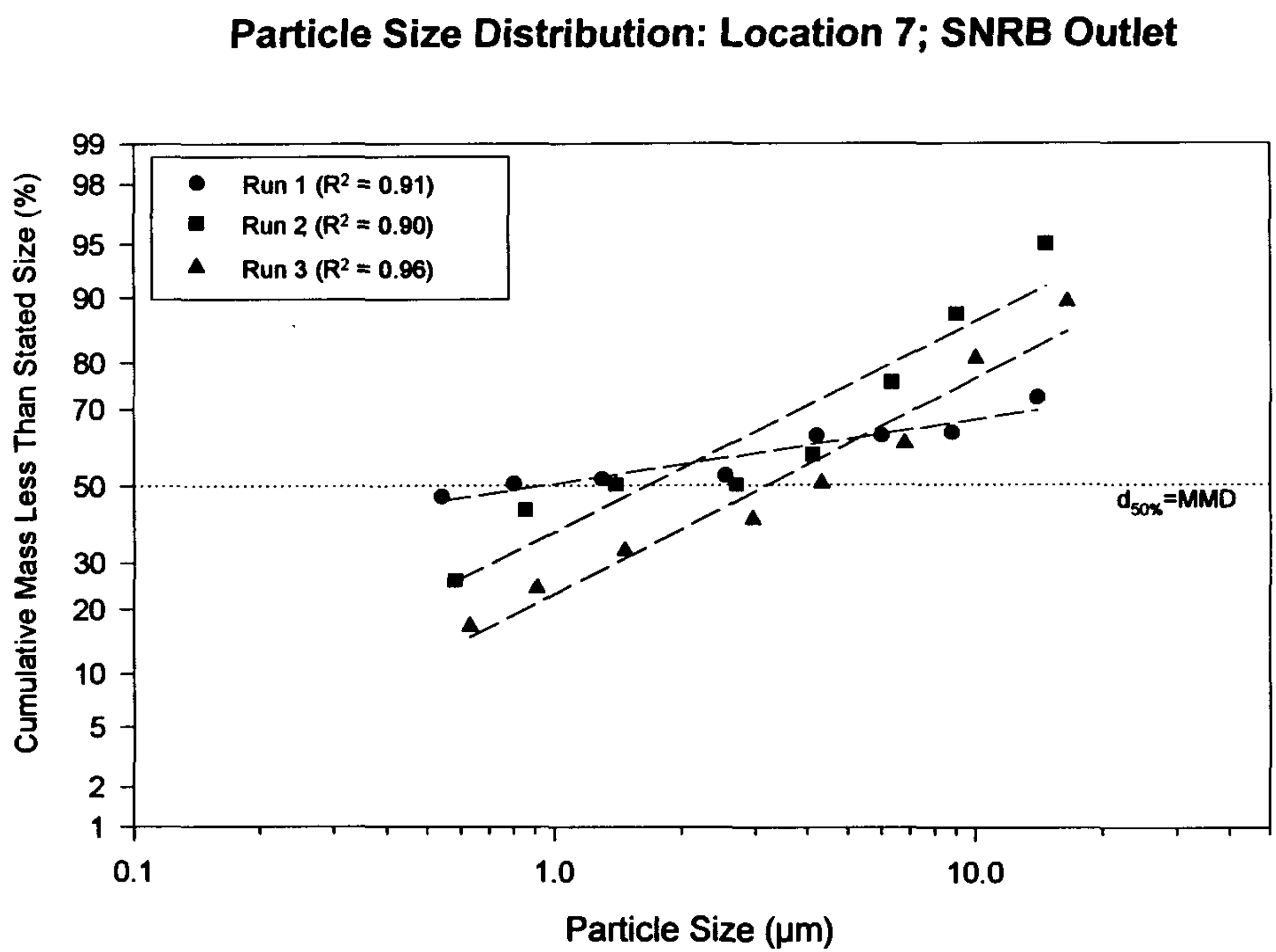


Figure III-3. Particle Size Distribution Measured at Location 7

Particle Size Distribution: Location 10; ESP Inlet

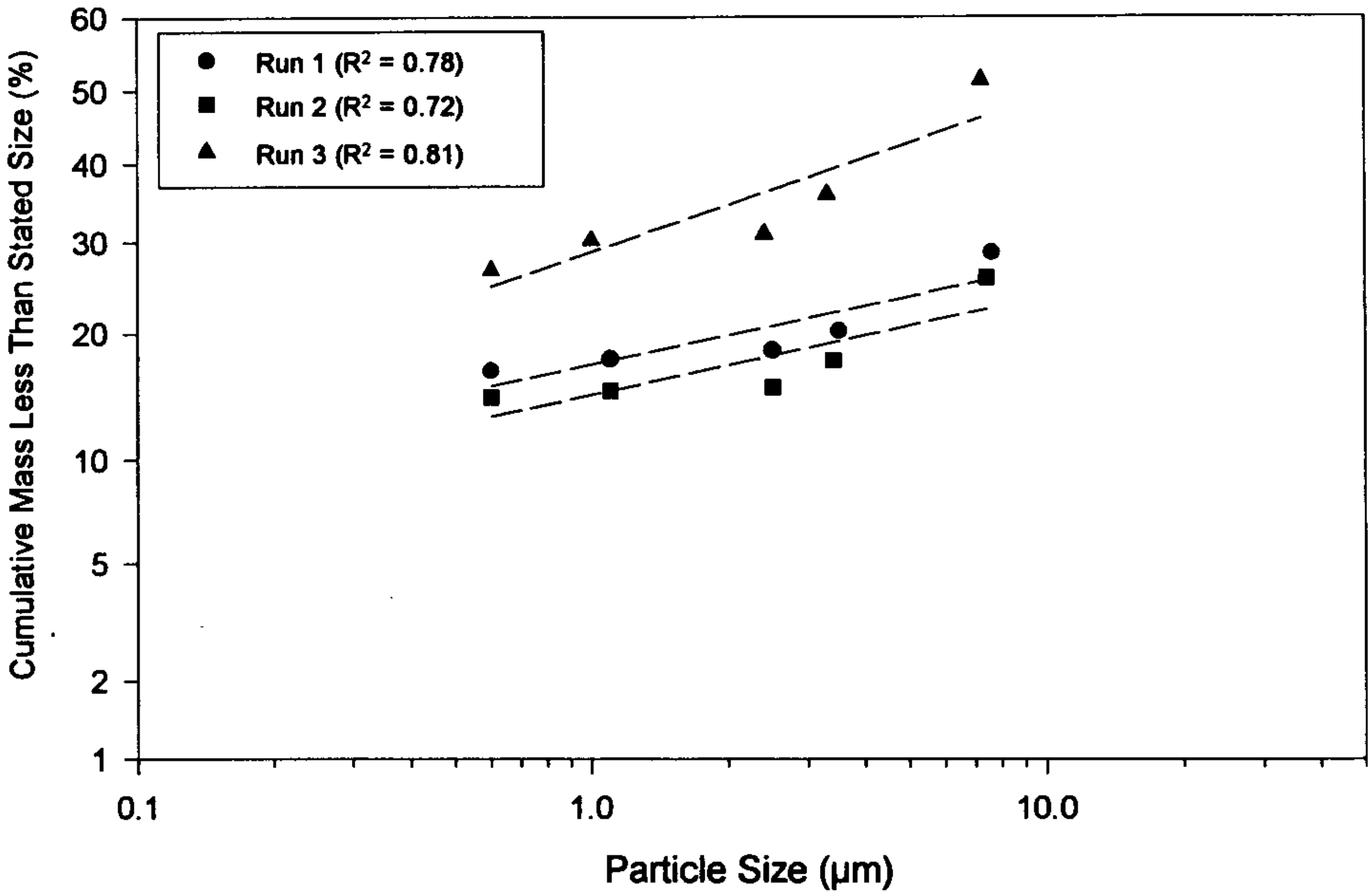


Figure III-4. Particle Size Distribution Measured at Location 10

Particle Size Distribution: Location 12; ESP Outlet

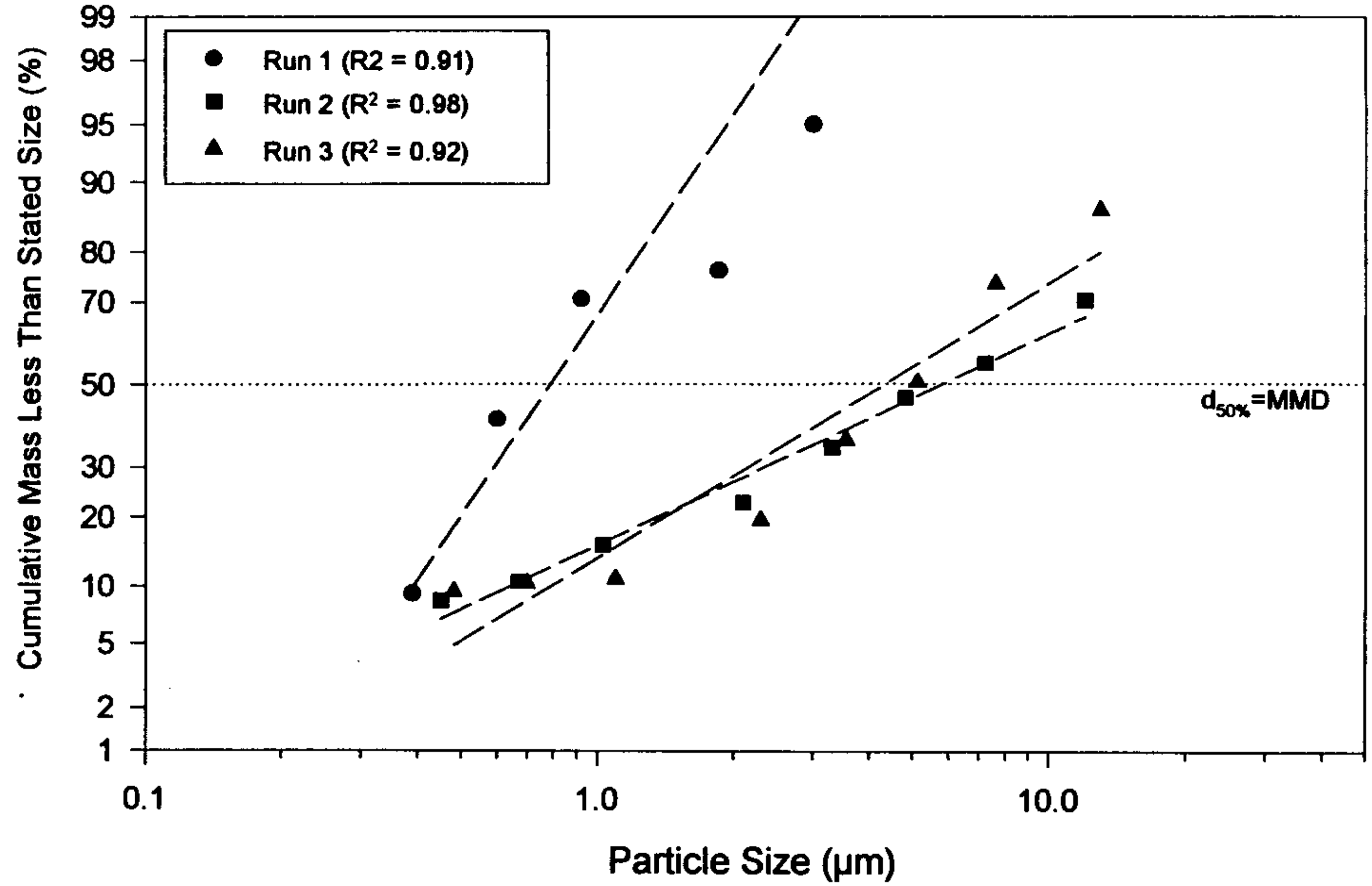


Figure III-5. Particle Size Distribution Measured at Location 12

TABLE III-3. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R1-L5

Cyclone No.	d50(a) (μm)	Net Weight (g)	Percent Total	Cumulative <d50 (%)
1	13.5	3.6886	71.8	28.2
II	7.5	0.6836	13.3	14.9
III	6.3	0.2773	5.4	9.5
IV	2.6	0.1934	3.8	5.7
V	1.2	0.0949	1.8	3.9
Filter	0	0.1992	3.9	0
TOTAL		5.1370		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-4. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R2-L5

Cyclone No.	d50(a) (μm)	Net Weight (g)	Percent Total	Cumulative <d50 (%)
1	12.8	6.8015	73.1	26.9
II	7.0	1.2777	13.7	13.1
III	5.8	0.4007	4.3	8.6
IV	2.3	0.2705	2.9	5.9
V	1.1	0.2109	2.3	3.7
Filter	0	0.3405	3.7	0
TOTAL		9.3018		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-5. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R3-L5

Cyclone No.	d50(a) (μm)	Net Weight (g)	Percent Total	Cumulative <d50 (%)
1	13.6	6.7702	77.6	22.4
II	7.6	1.0679	12.2	10.2
III	6.3	0.3233	3.7	6.5
IV	2.0	0.2305	2.6	3.9
V	1.2	0.1878	2.2	1.7
Filter	0	0.1499	1.7	0
TOTAL		9.3018		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-6. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R1-L7

Stage No.	d50(a) (μm)	Net Weight (mg)	Percent Total	Cumulative <d50 (%)
0	14	51.95	27.3	72.7
1	8.80	16.1300	8.5	64.2
2	6.00	1.4100	0.7	63.5
3	4.20	0.0000	0.0	63.5
4	2.55	20.2250	10.6	52.9
5	1.30	1.6800	0.9	52.0
6	0.80	2.6450	1.4	50.6
7	0.54	6.4100	3.4	47.2
Backup Filter	0	89.9250	47.2	0
TOTAL		190.38		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-7. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R2-L7

Stage No.	d50(a) (μm)	Net Weight (mg)	Percent Total	Cumulative <d50 (%)
0	14.7	0.69	5.0	95.0
1	9.00	0.9800	7.1	87.9
2	6.30	1.6400	5.0	76.0
3	4.10	2.4100	17.4	58.6
4	2.70	1.1200	8.1	50.5
5	1.40	0.0000	0.0	50.5
6	0.85	0.9700	7.0	43.5
7	0.58	2.4100	17.4	26.0
Backup Filter	0	3.6000	26.0	0
TOTAL		13.82		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-8. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R3-L7

Stage No.	d50(a) (μm)	Net Weight (mg)	Percent Total	Cumulative <d50 (%)
0	16.5	3.39	10.5	89.5
1	10.00	2.8100	8.7	80.7
2	6.80	6.2200	10.5	61.4
3	4.30	3.4400	10.7	50.7
4	2.95	3.1300	9.7	41.0
5	1.47	2.5800	8.0	33.0
6	0.91	2.8200	8.8	24.3
7	0.63	2.3500	7.3	17.0
Backup Filter	0	5.4600	17.0	0
TOTAL		32.2		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-9. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R1-L10

Cyclone No.	d50(a) (μm)	Net Weight (g)	Percent Total	Cumulative <d50 (%)
1	7.6	0.5260	71.3	28.7
II	3.5	0.0624	8.5	20.2
III	2.5	0.0137	1.9	18.3
IV	1.1	0.0056	0.8	17.6
V	0.6	0.0076	1.0	16.6
Filter	0	0.1221	16.6	0
TOTAL		0.737		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-10. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R2-L10

Cyclone No.	d50(a) (μm)	Net Weight (g)	Percent Total	Cumulative <d50 (%)
1	7.4	0.6357	74.3	25.7
II	3.4	0.0709	8.3	17.4
III	2.5	0.0199	2.3	15.1
IV	1.1	0.0021	0.2	14.9
V	0.;6	0.0044	0.5	14.3
Filter	0	0.1228	14.3	0
TOTAL		0.856		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-11. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R3-L10

Cyclone No.	d50(a) (μm)	Net Weight (g)	Percent Total	Cumulative <d50 (%)
1	7.2	0.2429	48.7	51.3
II	3.3	0.0771	15.4	3.3
III	2.4	0.0249	5.0	2.4
IV	1.0	0.0036	0.7	1.0
V	0.6	0.0173	3.5	0.6
Filter	0	0.1333	26.7	0
TOTAL		0.499		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-12. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R1-L12

Stage No.	d50(a) (μm)	Net Weight (mg)	Percent Total	Cumulative <d50 (%)
0	10	0.00	0.0	100.0
1	6.30	0.00	0.0	100.0
2	4.30	0.00	0.0	100.0
3	3.00	0.57	5.0	95.0
4	1.85	2.12	18.5	76.6
5	0.92	0.67	5.8	70.8
6	0.60	3.37	29.3	41.4
7	0.39	3.70	32.2	9.2
Backup Filter	0	1.06	9.2	0
TOTAL		11.49		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-13. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R2-L12

Stage No.	d50(a) (μm)	Net Weight (mg)	Percent Total	Cumulative <d50 (%)
0	12	2.44	29.6	70.4
1	7.20	1.2200	14.8	55/6
2	4.80	0.7200	29.6	46.8
3	3.30	1.0100	12.3	34.6
4	2.10	0.9800	11.9	22.7
5	1.03	0.6000	7.3	15.4
6	0.67	0.4000	4.9	10.6
7	0.45	0.1700	2.1	8.5
Backup Filter	0	0.7000	8.5	0
TOTAL		8.24		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

TABLE III-14. PARTICLE SIZE DISTRIBUTION SUMMARY FOR R3-L12

Stage No.	d50(a) (μm)	Net Weight (mg)	Percent Total	Cumulative <d50 (%)
0	13	1.35	13.4	86.6
1	7.60	1.2700	12.6	74.0
2	5.10	2.3400	13.4	50.7
3	3.55	1.4500	14.4	36.3
4	2.30	1.6900	16.8	19.5
5	1.10	0.8700	8.6	10.8
6	0.70	0.0500	0.5	10.3
7	0.48	0.0900	0.9	9.4
Backup Filter	0	0.9500	9.4	0
TOTAL		10.06		

(a) d50 is the 50 percent particle cut diameter for each impactor stage.

D. Ultimate/Proximate, Loss on Ignition, and Unburned Carbon

Ultimate/proximate analysis results for the composite coal samples collected on the days associated with Runs 1, 2, and 3 of the Method 29 (multi-metal) train sampling are provided in Table III-15. Loss on ignition and unburned (combustible) carbon results for the composite solid process stream samples collected on the days associated with Runs 1, 2, and 3 of the Method 29 train are presented in Table III-16. The loss on ignition represents the ash (percent) subtracted from 100 percent; the combustible carbon represents carbonate carbon subtracted from total carbon.

E. Trace Elements

Method 29 and Solid Samples

Results of the analysis of trace elements in Method 29 and solid process samples are presented, respectively, in Tables III-17 and III-18 for ICP-AES (inductively coupled plasma atomic emission spectrometry) analysis of chromium (Cr), cadmium (Cd), nickel (Ni), barium (Ba), cobalt (Co), manganese (Mn), vanadium (V), and beryllium (Be), Tables III-19 and III-20 for GF-AAS (graphite furnace atomic absorption spectrometry) analysis of arsenic (As), lead (Pb), antimony, (Sb) and selenium (Se), and Tables III-21 and III-22 for CV-AAS (cold vapor atomic absorption spectrometry) analysis of mercury (Hg). For all analyses, data were treated as follows:

- Sample results were not corrected for Location 7 or Location 12 Method 29 train blanks. Train blank emission levels were calculated by using the average gas sample volume from the three runs at the associated location.

- Sample results were not corrected for Method 29 field reagent blanks. As noted in Section VII, the $KMNO_4$ (150840), 8N HCl (150841), and 5 percent HNO_3/10 percent H_2O_2 (150842) field reagent blanks were combined and prepared for mercury analysis. The 5 percent HNO_3/10 percent H_2O_2 reagent blank should have been prepared separately for element analysis by ICP-AES and GF-AAS. The filter reagent blank (150838) was combined with the laboratory digestion blank during preparation for ICP-AES and GF-AAS element analysis rather than being processed separately.

TABLE III-15. ULTIMATE/PROXIMATE RESULTS FOR COAL SAMPLES

	Coal Feed - Location 2(a)				
Parameter	Run 1 (APR2793)	Run 2 (APR2993)	Run 3 (APR3093)	Average	RSD% (b)
Moisture (%)	1.92	2.09	2.13	2.05	4.45
Ash (%)	11.9	11.7	12.28	11.96	2.01
Volatile (%)	39.37	38.94	38.71	39.01	0.70
Fixed Carbon (%)	48.73	49.36	49.01	49.03	0.53
Higher Heat Value (Btu/lb	12888	12916	12849	12884	0.21
Sulfur (%)	3.64	3.34	3.41	3.46	3.70
Carbon (%)	71.36	71.58	71.31	71.42	0.16
Hydrogen (%)	4.88	4.8	4.81	4.83	0.74
Nitrogen (%)	1.32	1.35	1.31	1.33	1.28
Oxygen (diff) (%)	6.9	7.23	6.88	7.00	2.29

(a) All results other than moisture on a dry basis.
(b) RSD = relative standard deviation.
(QPro Filename: ULTIMATE.WB1)

TABLE III-16. LOSS ON IGNITION AND UNBURNED CARBON RESULTS*

Sampling Location	Sample I.D.	Loss on Ignition (% wt.)	Unburned (Combustible) Carbon (% wt.)
Location 6 - SNRB Solids	R1-L6	11.11	0.03
	R2-L6	12.89	0.53
	R3-L6	11.92	0.49
	Average	11.97	0.35
	RSD (%)	6.08	64.82
Location 8 - Bottom Ash	R1-L8	-0.83	0.1
	R2-L8	-1.18	0.04
	R3-L8	-1.05	0.14
	Average	-1.02	0.09
	RSD (%)	14.16	44.03
Location 9 - Economizer Ash	R1-L9	-0.23	0.36
	R2-L9	-0.83	0.24
	R3-L9	-1.04	0.08
	Average	-0.70	0.23
	RSD (%)	49.03	50.60
Location 11 - Collected Flyash	R1-L11	6.78	5.61
	R2-L11	9.51	7.66
	R3-L11	10.51	8.66
	Average	8.93	7.31
	RSD (%)	17.65	17.37

*All results on a dry basis.

TABLE III-17. RESULTS FOR ICP-AES METALS ANALYSIS (μg/dscm)*

Location	Sample	Chromium Solid	Chromium Vapor	Chromium Total	Cadmium Solid	Cadmium Vapor	Cadmium Total	Nickel Solid	Nickel Vapor	Nickel Total	Barium Solid	Barium Vapor	Barium Total
Location 2 - SNRB Inlet	R1-L2	684	ND<1.4	685	7.40	ND<0.90	7.85	310	ND<1.9	311	933	ND<0.20	933
	R2-L2	266	ND<1.4	266	1.46	ND<0.90	1.91	151	ND<1.9	152	746	0.54	747
	R3-L2	1404	ND<1.4	1404	12.83	ND<0.90	13.28	668	ND<1.9	669	2971	0.31	2971
	Average	784	ND<1.4	785	7.23	ND<0.90	7.68	376	ND<1.9	377	1550	0.32	1550
Location 5 - Baghouse Inlet	R1-L5	389	ND<1.4	390	3.98	ND<0.90	4.43	180	ND<1.9	181	225	ND<0.20	225
	R2-L5	1142	1.19	1143	3.25	ND<0.90	3.70	791	2.12	793	143	1.63	145
	R3-L5	4932	2.44	4935	ND<60	ND<0.90	ND>60	283	2.62	286	100	ND<0.20	100
	Average	2154	1.68	2156	12.41	ND<0.90	12.71	418	1.90	420	156	0.61	157
Location 7 - SNRB Outlet	BL-L7**	0.79	ND<0.35	0.96	ND<15	ND<0.22	ND<15	ND<18	ND<0.48	ND<18	9.02	0.13	9.14
	R1-L7***	***	ND<0.35	ND<0.35	***	0.33	0.33	***	2.49	2.49	***	ND<0.05	ND<0.05
	R2-L7	10.74	0.32	11.06	0.97	0.13	1.10	88	0.36	88.77	7.43	0.20	7.63
	R3-L7	0.58	0.17	0.75	ND<15	0.18	ND<15	ND<18	ND<0.48	ND<18	6.35	0.20	6.55
	Average#	5.66	0.22	5.91	ND<15	0.18	ND<15	49	1.03	48.88	6.89	0.14	7.09
Location 10 - ESP Inlet	R1-L10	184	12.98	196	0.91	ND<0.90	1.36	60	9.59	70	332	8.60	340
	R2-L10	572	ND<1.4	572	4.92	0.75	5.66	313	ND<1.9	314	865	1.34	867
	R3-L10	404	18.91	423	3.02	0.35	3.37	153	9.98	163	832	35.58	868
	Average	386	10.86	397	2.95	0.52	3.47	175	6.84	182	676	15.17	692
Location 12 - ESP Outlet	BL-L12**	0.59	0.02	0.61	ND<15	ND<0.22	ND<15	ND<18	ND<0.48	ND<18	5.50	0.02	5.52
	R1-L12	0.49	0.37	0.86	ND<15	ND<0.22	ND<15	ND<18	ND<0.48	ND<18	5.94	0.43	6.38
	R2-L12	1.75	1.06	2.81	ND<15	ND<0.22	ND<15	ND<18	0.23	ND<18	9.46	1.28	10.74
	R3-L12	1.48	0.30	1.78	ND<15	ND<0.22	ND<15	ND<18	ND<0.48	ND<18	4.16	0.35	4.51
	Average	1.24	0.57	1.81	ND<15	ND<0.22	ND<15	ND<18	ND<0.48	ND<18	6.52	0.69	7.21
Field Reagent Blank##		5.2	NA		ND	NA		ND	NA		35.6	NA	

*Sample results not corrected for field reagent blanks.
**Sample results not corrected for Location 7 or Location 12 Method 29 train blanks.
***Front half composite from R1-L7 lost in sample preparation.
#Solid and total averages include only R2-L7 and R3-L7.
##Combination of filter, acetone, and 0.1N HNO_3 field reagent blanks for solid; back half field reagent blank (5%HNO_3/10%H_2O_2) for vapor not available (see Section VII). Results in ug
NA = Not available. ND = Not detected.
Detection limits based on gas sample volumes of 2 dscm for Location 2, 5, and 10, and 8 dscm for Location 7 and 12 and impinger volumes of 1000 mL.
QuattroPro: METVAL.wb1

TABLE III-17. RESULTS FOR ICP-AES METALS ANALYSIS (μg/dscm)* (Cont'd)

Location	Sample	Cobalt Solid	Cobalt Vapor	Cobalt Total	Manganese Solid	Manganese Vapor	Manganese Total	Vanadium Solid	Vanadium Vapor	Vanadium Total	Beryllium Solid	Beryllium Vapor	Beryllium Total
Location 2 - SNRB Inlet	R1-L2	127	ND<1.3	127	692	0.26	693	919	ND<1.3	919	37	ND<0.04	37
	R2-L2	43	1.12	45	238	0.76	239	605	0.62	606	17	ND<0.04	18
	R3-L2	303	ND<1.3	304	1431	2.14	1433	1836	ND<1.3	1837	81	ND<0.04	81
	Average	158	0.81	159	787	1.05	788	1120	ND<1.3	1121	45	ND<0.04	45
Location 5 - Baghouse Inlet	R1-L5	77	ND<1.3	78	605	4.05	609	525	ND<1.3	526	8	ND<0.04	8
	R2-L5	264	3.41	267	1269	111	1381	2852	2.78	2855	30	ND<0.04	30
	R3-L5	113	ND<1.3	114	764	8	771	822	4.31	826	11	ND<0.04	11
	Average	151	1.57	153	879	41	920	1400	2.58	1403	16	ND<0.04	16
Location 7 - SNRB Outlet	BL-L7**	ND<18	ND<0.32	ND<18	1.92	0.49	2.40	ND<16	ND<0.32	ND<16	ND<15	ND<0.01	ND<15
	R1-L7***	***	ND<0.32	ND<0.32	***	0.37	0.37	***	ND<0.32	ND<0.32	***	ND<0.01	ND<0.01
	R2-L7	2.54	0.15	2.69	3.14	0.60	3.74	ND<16	ND<0.32	ND<16	ND<15	ND<0.01	ND<15
	R3-L7	ND<18	ND<0.32	ND<18	1.78	0.93	2.71	ND<16	ND<0.32	ND<16	ND<15	ND<0.01	ND<15
	Average#	ND<18	ND<0.32	ND<18	2.46	0.63	3.23	ND<16	ND<0.32	ND<16	ND<15	ND<0.01	ND<15
Location 10 - ESP Inlet	R1-L10	23	ND<1.3	23	177	9	185	274	22.61	296	9	0.62	10
	R2-L10	97	ND<1.3	97	504	52	557	1031	ND<1.3	1032	33	ND<0.04	33
	R3-L10	74	8.23	82	438	14	452	512	35.56	548	22	1.24	23
	Average	64	3.18	67	373	25	398	606	19.61	625	21	0.63	22
Location 12 - ESP Outlet	BL-L12**	ND<18	ND<0.32	ND<18	1.79	0.76	2.55	ND<16	ND<0.32	ND<16	ND<15	ND<0.01	ND<15
	R1-L12	ND<18	ND<0.32	ND<18	2.62	0.42	3.03	ND<16	ND<0.32	ND<16	ND<15	ND<0.01	ND<15
	R2-L12	ND<18	ND<0.32	ND<18	3.46	30.72	34.18	2.92	ND<0.32	3.08	ND<15	ND<0.01	ND<15
	R3-L12	ND<18	ND<0.32	ND<18	3.47	1.73	5.21	0.36	ND<0.32	0.52	ND<15	ND<0.01	ND<15
	Average	ND<18	ND<0.32	ND<18	3.18	10.96	14.14	ND<16	ND<0.32	ND<16	ND<15	ND<0.01	ND<15
Field Reagent Blank##		3.5	NA		185	NA		ND	NA		0.1	NA	

*Sample results not corrected for field reagent blanks.
**Sample results not corrected for Location 7 or Location 12 Method 29 train blanks.
***Front half composite from R1-L7 lost in sample preparation.
#Solid and total averages include only R2-L7 and R3-L7.
##Combination of filter, acetone, and 0.1N HNO3 field reagent blanks for solid; field reagent blank (5%HNO3/10%H2O2) for vapor not available (see Section VII). Results in ug.
NA = Not available, ND = Not detected.
Detection limits based on gas sample volumes of 2 dscm for Location 2, 5, and 10, and 8 dscm for Location 7 and 12 and impinger volumes of 1000 mL.
(QPro Filename: METVAL)

TABLE III-18. RESULTS FOR ICP-AES ANALYSIS OF SOLID SAMPLES (ug/g)

Location	Run	Sample ID	Cr	Cd	Ni	Ba	Co	Mn	V	Be
Location 1 - Coal Feed	1	APR2793COAL*	14	ND<0.3	7	45	2	20	20	0.7
	2	APR2993COAL*	16	ND<0.3	9	51	3	19	27	0.5
	3	APR3093COAL*	14	ND<0.3	8	46	2	18	20	0.8
	Average		14.7	ND<0.3	8.0	47.3	2.3	19.0	22.3	0.7
Location 3 - Sorbent Feed	1	APR2793 Lime	1.3	ND<0.5	ND<0.2	14.1	7.6	4.9	3.8	ND<0.4
	2	APR2993 Lime	ND<0.7	ND<0.5	ND<0.2	11.6	ND<1.0	4.8	3.0	ND<0.4
	3	APR3093 Lime	ND<0.8	ND<0.5	ND<0.2	15.1	ND<1.0	5.4	3.3	ND<0.4
	Average		ND<0.8	ND<0.5	ND<0.2	13.6	2.9	5.0	3.3	ND<0.4
Location 6 - SNRB Solids	1	APR2793SNRB	31.4	ND<0.5	12.0	8.1	6.7	37.2	53.4	ND<0.4
	2	APR2993SNRB	31.9	ND<0.5	19.2	9.0	9.7	36.5	74.3	1.1
	3	APR3093SNRB**	34.8	ND<0.5	11.9	8.2	8.9	34.3	53.3	1.1
	Average		32.7	ND<0.5	14.4	8.4	8.4	36.0	60.3	0.8
Location 8 - Bottom Ash	1	APR2793BOTT	102.3	3.0	42.1	182.8	7.8	149.3	126.3	4.8
	2	APR2993BOTT	115.4	2.6	75.3	212.1	24.7	139.1	189.3	5.4
	3	APR3093BOTT	111.5	2.9	45.4	147.4	15.5	143.3	129.7	4.9
	Average		109.7	2.8	54.2	180.8	16.0	143.9	148.4	5.0
Location 9 - Economizer Ash	1	APR2793ECON	122.8	2.5	50.9	171.1	13.4	151.0	129.8	5.0
	2	APR2993ECON**	120.9	18.4	59.2	219.6	22.6	147.8	172.9	6.2
	3	APR3093ECON	115.5	4.3	48.3	178.3	11.1	134.0	139.2	5.5
	Average		119.7	8.4	52.8	189.7	15.7	144.2	147.3	5.6
Location 11 - ESP Ash	1	APR2793 ESPA	124.5	1.3	52.2	232.5	19.2	134.0	158.3	6.1
	2	APR2993 ESPA	124.3	1.5	59.7	244.6	15.4	121.1	189.7	6.7
	3	APR3093 ESPA	122.3	0.8	59.1	247.2	20.6	109.9	195.2	6.8
	Average		123.7	1.2	57.0	241.4	18.4	121.7	181.1	6.6

**Analyses conducted by Commercial Testing and Engineering*

**Result represents average of duplicate results.

(QPro Filename: ICPSOL.WB1)

TABLE III-19. RESULTS FROM GF-AAS ANALYSIS OF METHOD 29 SAMPLES (μg/dscm)**

Sampling Location	Sample I.D.	Arsenic Solid	Arsenic Vapor	Arsenic Total	Lead Solid	Lead Vapor	Lead Total	Antimony Solid	Antimony Vapor	Antimony Total	Selenium Solid	Selenium Vapor	Selenium Total
Location 2 - SNRB Inlet	R1-L2	505.24	0.40	505.64	216.53	ND< 0.15	216.61	7.67	ND< 0.35	7.85	150.09	ND< 0.75	150.46
	R2-L2	298.40	0.64	299.04	119.47	ND< 0.15	119.54	9.11	ND< 0.35	9.29	89.07	ND< 0.75	89.44
	R3-L2	574.73	ND< 0.25	574.86	221.56	ND< 0.15	221.64	8.38	ND< 0.35	8.56	203.35	ND< 0.75	203.72
	Average	459.46	0.39	459.85	185.85	ND< 0.15	185.93	8.39	ND< 0.35	8.56	147.50	ND< 0.75	147.88
Location 5 - Baghouse Inlet	R1-L5	263.50	0.36	263.86	27.34	0.18	27.51	8.19	ND< 0.35	8.36	113.14	ND< 0.75	113.51
	R2-L5	565.10	0.65	565.76	47.76	ND< 0.15	47.84	18.44	ND< 0.35	18.61	155.73	ND< 0.75	156.10
	R3-L5	446.99	8.17	455.16	46.46	1.32	47.78	13.39	ND< 0.35	13.57	137.54	6.05	143.59
	Average	425.20	3.06	428.26	40.52	0.52	41.04	13.34	ND< 0.35	13.52	135.47	2.27	137.74
Location 7 - SNRB Outlet	BL-L7*	0.01	ND< 0.06	ND< 0.06	ND< 0.25	0.04	0.29	0.06	0.09	0.16	0.25	ND< 0.19	0.35
	R1-L7***	***	ND< 0.06	ND< 0.06	***	ND< 0.04	ND< 0.04	***	ND< 0.09	ND< 0.09	***	ND< 0.19	ND< 0.19
	R2-L7	2.13	ND< 0.06	2.16	0.78	0.32	1.10	1.58	ND< 0.09	1.63	0.06	ND< 0.19	ND< 0.19
	R3-L7	0.23	ND< 0.06	0.26	0.01	ND< 0.04	ND< 0.04	0.08	ND< 0.09	0.12	0.03	ND< 0.19	ND< 0.19
	Average#	1.18	ND< 0.06	1.21	0.39	0.12	0.56	0.83	ND< 0.09	0.88	0.04	ND< 0.19	ND< 0.19
Location 10 - ESP Inlet	R1-L10	141.96	17.47	159.42	61.36	7.22	68.59	3.48	1.17	4.64	39.69	46.0	85.69
	R2-L10	546.15	0.70	546.86	192.82	ND< 0.15	192.90	15.54	ND< 0.35	15.72	90.77	1.68	92.45
	R3-L10	232.75	66.79	299.54	124.55	19.73	144.28	6.52	7.26	13.78	59.16	135.4	194.61
	Average	306.96	28.32	335.28	126.25	13.52	135.26	8.51	2.87	11.38	63.21	61.0	124.25
Location 12 - ESP Outlet	BL-L12*	ND< 0.19	ND< 0.06	ND< 0.19	0.25	0.05	0.30	0.08	ND< 0.09	0.12	0.24	2.58	2.82
	R1-L12	1.66	0.13	1.79	0.05	ND< 0.04	0.07	0.22	ND< 0.09	0.26	86.14	ND< 0.19	86.23
	R2-L12	6.11	0.27	6.38	0.25	0.10	0.35	0.20	ND< 0.09	0.24	7.57	0.27	7.84
	R3-L12	1.70	0.14	1.84	ND< 0.25	ND< 0.04	ND< 0.25	0.14	ND< 0.09	0.18	12.50	0.33	12.83
	Average	3.16	0.18	3.34	0.15	0.05	0.21	0.18	ND< 0.09	0.23	35.40	0.23	35.64
Field Reagent Blank##		0.73	NA		ND	NA		4.17	NA		ND	NA	

*Sample results not corrected for Location 7 or Location 12 Method 29 train blanks.
**Sample results not corrected for field reagent blanks.
***Front half composite from R1-L7 lost in sample preparation.
#Solid and total averages include only R2-L7 and R3-L7.
##Combination of filter, acetone, and 0.1N HNO3 field reagent blanks for solid; field reagent blank for vapor (5%HNO3/10%H2O2) not available (see Section VII). Results in ug.
NA = Not available. ND = Not detected.
Detection limits based on gas sample volumes of 2 dscm for Location 2, 5, and 10 and 8 dscm for Location 7 and 12.
(QPro Filename: GFVAL.WB1)

TABLE III-20. RESULTS OF GF-AAS ANALYSIS OF SOLID SAMPLES (µg/g)

Sampling Location	Run	Sample I.D.	As	Pb	Sb	Se
Location 1 - Coal Feed	1	APR2793COAL*	4.0	5.0	ND< 1.0	3.0
	2	APR2993COAL*	6.0	5.0	ND< 1.0	3.0
	3	APR3093COAL*	5.0	6.0	ND< 1.0	2.0
	Average		5.0	5.3	ND< 1.0	2.7
Location 3 - Sorbent Feed	1	APR2793LIME	1.14	ND< 0.3	ND< 0.3	ND< 0.5
	2	APR2993LIME	1.54	ND< 0.3	0.06	ND< 0.5
	3	APR3093LIME	1.74	ND< 0.3	ND< 0.3	ND< 0.5
	Average		1.47	ND< 0.3	ND< 0.3	ND< 0.5
Location 6 - SNRB Solids	1	APR2793SNRB	60.4	3.6	0.48	5.18
	2	APR2993SNRB	80.60	4.28	0.69	5.83
	3	APR3093SNRB**	84.70	3.94	0.56	6.44
	Average		75.23	3.94	0.58	5.82
Location 8 - Bottom Ash	1	APR2793BOTT	4.69	6.65	0.31	ND< 0.5
	2	APR2993BOTT	6.14	5.69	ND< 0.3	ND< 0.5
	3	APR3093BOTT	3.28	6.16	ND< 0.3	ND< 0.5
	Average		4.70	6.17	ND< 0.3	ND< 0.5
Location 9 - Economizer Ash	1	APR2793ECON	130	6.15	0.78	ND< 0.5
	2	APR2993ECON**	16.05	5.21	ND< 0.3	ND< 0.5
	3	APR3093ECON	53.6	4.34	ND< 0.3	ND< 0.5
	Average		66.55	5.23	0.36	ND< 0.5
Location 11 - ESP Ash	1	APR2793ESPA	159	31.6	1.26	9.41
	2	APR2993ESPA	203	33.2	1.43	10.5
	3	APR3093ESPA	219	34.2	1.48	12.3
	Average		194	33	1.39	10.7

*Analyses conducted by Commercial Testing and Engineering.
**Results are average of duplicate samples.

(QPro Filename: GFSOL.WB1)

TABLE III-21. RESULTS FROM CV-AAS ANALYSIS OF MERCURY IN METHOD 29 SAMPLES (μg/dscm)***

Sampling Location	Sample I.D	Solid	Vapor #	Total
Location 2 - SNRB Inlet	R1-L2	4.55	2.09	6.64
	R2-L2	5.47	2.91	8.37
	R3-L2	9.29	5.32	14.61
	Average	6.44	3.44	9.88
Location 5 - Baghouse Inlet	R1-L5	4.93	2.75	7.68
	R2-L5	9.64	0.21	9.85
	R3-L5	10.40	1.16	11.57
	Average	8.32	1.38	9.70
Location 7 - SNRB Outlet	BL-L7*	ND< 0.005	0.05	0.05
	R1-L7	**	11.44	11.44
	R2-L7	0.023	11.57	11.59
	R3-L7	ND< 0.005	15.51	15.51
	Average##	0.013	12.84	13.55
Location 10 - ESP Inlet	R1-L10	ND< 0.11	12.61	12.61
	R2-L10	3.59	8.46	12.05
	R3-L10	0.77	9.79	10.56
	Average	1.47	10.29	11.74
Location 12 - ESP Outlet	BL-L12*	ND< 0.005	0.85	0.85
	R1-L12	ND< 0.005	9.45	9.45
	R2-L12	0.008	10.13	10.13
	R3-L12	ND< 0.005	11.66	11.66
	Average	ND< 0.005	10.41	10.42
Field Reagent Blank###		0.035	0.31	

*Sample results not corrected for Location 7 or 12 Method 29 train blanks.
**Front half composite from R1-L7 lost in sample preparation.
***Sample results are corrected for field reagent blanks.
#Vapor phase includes combination of results from HNO3/H2O2 and KMNO4 impingers.
##Solid and total averages include only R2-L7 and R3-L7.
###Combination of filter, acetone, and 0.1N HNO3 field reagent blanks for solid; combination of 8N HCl, KMNO4, and HNO3/H2O2 field reagent blanks for vapor. Blank results are in ug.
(QPro Filename: MERCTOT.WB1)

TABLE III-22. RESULTS FOR CV-AAS ANALYSIS OF MERCURY IN SOLID SAMPLES

Location	Run	Sample I.D	Concentration (µg/g)
Location 1 - Coal Feed	1	APR2793COAL*	0.14
	2	APR2993COAL*	0.14
	3	APR3093COAL*	0.11
	Average		0.13
Location 3 - Sorbent Feed	1	APR2793LIME	ND< 0.02
	2	APR2993LIME	ND< 0.02
	3	APR3093LIME	ND< 0.02
	Average		ND< 0.02
Location 6 - SNRB Solids	1	APR2793SNRB	ND< 0.02
	2	APR2993SNRB	ND< 0.02
	3	APR3093SNRB	ND< 0.02
	Average		ND< 0.02
Location 8 - Bottom Ash	1	APR2793BOTT	ND< 0.02
	2	APR2993BOTT	ND< 0.02
	3	APR3093BOTT	ND< 0.02
	Average		ND< 0.02
Location 9 - Economizer Ash	1	APR2793ECON	ND< 0.020
	2	APR2993ECON	0.021
	3	APR3093ECON	ND< 0.020
	Average		ND< 0.020
Location 11 - ESP Ash	1	APR2793ESPA	0.272
	2	APR2993ESPA	0.402
	3	APR3093ESPA	0.520
	Average		0.398

*Coal analyses conducted by Commercial Testing and Engineering.

(QPro Filename: MERCSOL.WB1)

- Samples were corrected for laboratory blanks.
- Averages were calculated by averaging results for the number of runs which had concentrations above the method detection limit. If an analyte was detected in all three runs, the average across the three runs was determined. If an analyte was not detected in one or two of the three runs, the average was determined using half of the detection limit for those runs in which the analyte was not detected; if the average was less than the highest detection limit, the result is reported as ND< (highest detection limit). In cases where an analyte was not detected in all three runs, the average was calculated as the average of the three detection limits.
- Averages for total element concentrations in Method 29 samples were calculated as described above rather than adding the average solid and vapor results.
- Coal results are on a dry basis.
- The front half (probe rinses and filter) composite from the Method 29 sample collected in Run 1 at Location 7 (SNRB™ Outlet) was lost during sample preparation. Solid phase averages are calculated without including this sample. The total element results will be biased low for this run.
- Detection limits were calculated by using three times the standard deviation of replicate (triplicate or more) results from blanks or low-level samples.

For the ICP-AES analyses of Method 29 samples (Table III-17) trace elements were detected at levels above blank train levels at all inlet locations. At the outlet locations, element emission levels are not significantly above train blank levels in many cases. Run 2 at Location 12 appears to be an exception where emission levels for detected analytes are above train blank levels. Results for ICP-AES analysis of solid samples (Table III-18) are fairly consistent across the three sampling days.

For the GF-AAS analyses of Method 29 samples (Table III-19), consistent emission levels above train blanks for the three runs were obtained at the inlet locations. Most concentrations at Location 7 (SNRB™ Outlet) are close to train blank levels; while most concentrations at Location 12 (ESP Outlet) are above train blank levels. As with the ICP-AES analyses, the results for the GF-AAS analysis of solid samples are fairly consistent across the 3 sampling days. One exception is the arsenic concentration in the economizer ash which ranged from 16 $\mu g/g$ in Run 2 to 130 $\mu g/g$ in Run 1.

Results from CV-AAS analysis of total mercury in Method 29 samples (Table III-21) are remarkably consistent across the triplicate runs. In general, the distribution of mercury between solid and vapor phases appears to favor the solid phase for inlet locations and the vapor phase for outlet locations. As indicated in Table III-21, the vapor phase results are a combination of Method 29 back half (H_2O_2 impingers) and $KMnO_4$ impinger results. In most cases, the amount of mercury in the back half was higher than that detected in the $KMnO_4$ impingers. For the CV-AAS analysis of solid samples (Table III-22), only the ESP ash had levels of mercury above the levels in the feed coal.

Mercury Speciation

Mercury speciation measurements were made by Frontier Geosciences. The measurements were performed at the ESP and SNRB™ outlets during the time that the Method 29 train was collected at the same locations by EER. The mercury speciation sampler was operated for shorter durations than the multiple metals trains but during the same sampling period.

A description of the sampling and analytical method follows that of Bloom, and is presented in Appendix A. Briefly, the Bloom mercury speciation sampling train consisted of 2 pairs of solid sorbent traps, through which flue gas was pulled at a rate of 0.5 L/min. The first pair of traps contained KCl-impregnated soda lime for measurement of ionic mercury (Hg^{2+}) and methyl mercury (both species measured after ethylation), and the second pair of traps contained iodated carbon for metallic mercury. Each pair of traps (primary and backup) was analyzed separately to determine possible breakthrough. The sampler was not operated isokinetically, so particulate-bound mercury, if present, was not representatively sampled.

The detailed results are given in Appendix A. Table III-23 summarizes the mercury speciation results. The data are blank-corrected and reported on a dry gas basis. For the ESP outlet, mercury emissions averaged 6.5 ± 1 $\mu g/dscm$. All of the methyl mercury results are suspect due to an artifact discovered after the completion of this effort (see Appendix A). The traps showed very high collection of oxidized mercury (>98 percent

TABLE III-23. MERCURY SPECIATION RESULTS[(e)]

Sample	Blank-Corrected Mercury, Bloom Method (μg/dscm)				Battelle Method 29 (μg/dscm)[(a,b)]
	Ionic	Methyl	Hg°	Total	
ESP Outlet					
L12 4/27/93 13:17-17:19	5.82	1.61	0.27	7.70	9.4
L12 4/29/93 13:14-18:28	4.56	0.92	0.46	5.94	10.1
L12 4/29/93 19:25-21:25	4.49	0.80	0.16	5.45	
L12 4/30/93 9:39-14:06	5.05	1.44	0.36	6.85	11.7
L12 4/30/93 14:39-18:48	6.23	2.11	(0.36)[(c)]	(8.70)[(c)]	
SNRB™ Outlet[(d)]					
L7 4/27/93 10:56-15:23	3.09[(d)]	0.33[(d)]	4.23	7.65	11.4
L7 4/29/93 12:51-17:31	5.59[(d)]	1.10[(d)]	2.88	9.57	11.5
L7 4/29/93 17:45-20:45	4.74[(d)]	0.80[(d)]	3.64	9.18	
L7 4/30/93 9:30-14:11	2.57[(d)]	0.45[(d)]	3.32	6.34	15.5
L7 4/30/93 14:59-18:29	2.97[(d)]	0.58[(d)]	4.70	8.25	

(a) Collected during the same sampling period but for a longer duration.
(b) Results not blank-corrected.
(c) A portion of the sampler lost, thus these are minimum values. This sample was not used for the data average.
(d) *For all SNRB™ samples, the actual ionic/methyl mercury levels may be higher than reported* due to apparent breakthrough into the backup solid sorbent.
(e) Methyl mercury results are suspect. See Appendix A for detailed explanation.

on the first sorbent trap). The percentage of the mercury present as ionic mercury averaged 76 percent; as methyl mercury averaged 19 percent (suspect data; see Appendix A); and as Hg^0 averaged 4 percent. The significance of the ionic mercury is that it is the most readily captured form in wet FGD systems[1].

For the SNRB™ outlet, the samples showed oxidized mercury breakthrough into the second soda lime trap (backup). Thus, for the SNRB™ results, Hg^0 concentrations may be overestimated. The value for total mercury, which is not affected by the sorbent breakthrough, averaged 8.2 $\pm$1.2 μg/dscm.

There is high between-day variability in the mercury emissions at each location. Each pair of ESP and SNRB™ emissions measurements compare well, with the exception of the samples from 4/29/93. On the 29th, considerably higher mercury emissions are found for SNRB™ than for the ESP.

Comparison of Mercury Speciation and Method 29 Train Results

Table III-23 gives the corresponding mercury emissions levels measured by way of Method 29. The mercury speciation sampler was operated for shorter durations than the multiple metals trains but during the same sampling period. The Method 29 measurements are consistently higher that the corresponding mercury speciation results. The differences are larger than can be explained by Method 29 data not being blank-corrected, and the Method 29 results do not suggest large particulate-phase mercury. The factors that governed the collection of mercury by the two methods are not completely understood. (Method 29 and the Bloom speciation method have been recently subjected to a field comparison[2].)

Using the coal mercury concentration (0.11-0.14 μg/g), the average coal feed rate, and the average ESP and SNRB™ outlet flue gas flow rates, the expected concentration of mercury in the flue gas can be calculated[3]. Assumptions include coal is the only source of mercury and 100 percent mercury volatilization. If 2.17 percent of the boiler flue gas is diverted to the SNRB™ process (based on the ratio of average system inlet flow rates), this corresponds to a calculated emission of 10-12 μg/dscm for SNRB™ and 11-14 μg/dscm for the ESP. This compares well with Method 29 measurements.

Frontier Geosciences performed additional measurement of total mercury in the coal samples. In the samples from April 27, 29, and 30; 0.12, 0.10, and 0.13 $\mu g/g$ of mercury was found. These results compare well with the coal mercury levels found at Battelle.

Comparison of Ash and Metal Concentration Measured at Locations 2 and 10

Locations 2 and 10 are, respectively, the inlet locations to the SNRB™ system and ESP. They both can be used to measure concentrations of HAPs exiting the boiler (see Figure I-3). Location 2 had no control devices between it and the outlet of the boiler. Because it was in the slipstream from the boiler exit and had a flow of only about 2.17 percent of the total flue gas, it was not a normal location in which to measure the ash and metals content of flue gas exiting the boiler. However, Location 10 also was not ideal as a location for the boiler exit. Location 10 was a point in the duct downstream of the point where the SNRB™ exit flue gas rejoined the main flue gas prior to entering the ESP. The effect was to mix clean flue gas from the SNRB™ system with dirty flue gas from the boiler at a ratio of about 2.2/97.8. Thus the flue gas at Location 10 could be expected to have concentrations of HAPs in the range 98 to 100 percent of the flue gas leaving the boiler (assuming the SNRB™ system to be between 100 and 0 percent efficient). In addition, a complete traversing of Location 10 could not be accomplished (see Section VII). Particulate-phase trace metal concentrations at the ESP inlet may be biased low at Location 10 (see Section IV).

Table III-24 offers a comparison of measured concentrations of ash and trace metals at Locations 2 and 10 which are expected to be approximately equal since both represent flue gas leaving the boiler. The ratio of average measured ash concentrations at Location 10/Location 2 is 0.87. With the exception of antimony, the ratios for metals primarily in the particle phase and measured by GF-AAS was in the range 0.73 to 0.84. The ratio for mercury measured by CV-AAS was 1.04. Note that for the eight metals measured by ICP-AES the ratio was in the range 0.42 to 0.56. These unexpected differences suggest that some of the problems identified with sampling at these locations may have affected the

TABLE III-24. COMPARISON OF SELECTED MEASUREMENTS OF SUBSTANCES AT LOCATIONS 2 AND 10

Substance	SNRB™ Inlet Location 2	ESP Inlet Location 10	Ratio of Location 10/ Location 2	Analytical Method
Ash(a)	8.5	9.0	1.06	Gravimetric
Hg	9.88	10.3	1.04	CV-AAS
Cr	784	397	0.51	ICP-AES
Cd	7.23	3.32	0.46	ICP-AES
Ni	376	182	0.48	ICP-AES
Ba	1,550	692	0.45	ICP-AES
Co	158	67	0.42	ICP-AES
Mn	788	398	0.51	ICP-AES
V	1,120	625	0.56	ICP-AES
Be	45.1	22	0.49	ICP-AES
As	460	335	0.73	GF-AAS
Pb	186	135	0.73	GF-AAS
Sb	8.39	11.3	1.35	GF-AAS
Se	148	124	0.84	GF-AAS

(a) Units for ash are g/dscm. Units for metals are μg/dscm.

results. The effect of the differences on mass balance calculations will be discussed in Section IV.

F. Chloride/Fluoride

Chloride/fluoride results for gas emission samples are presented in Table III-25. Results for chloride/fluoride analysis of composite solid process samples collected on days corresponding to Method 26A gas sampling runs are presented in Table III-26.

Data presented in these tables were treated as follows:

- Sample results were not corrected for Location 7 or Location 12 Method 26A train blanks, field reagent blanks, or laboratory blanks. Train and field reagent blank concentrations were calculated using the average gas sample volume from all locations.

- Averages were calculated by averaging results for the number of runs which had concentrations above the method detection limit. If an analyte was detected in all three runs, the average across the three runs was determined. If an analyte was not detected in one or two of the three runs, the average was determined using half of the detection limit for those runs in which the analyte was not detected; if the average was less than the highest detection limit, the result is reported as ND< (highest detection limit). In cases where an analyte was not detected in all three runs, the average was calculated as the average of the three detection limits.

- The detection limit was determined by multiplying the standard deviation of eight determinations by the student's t value (see Section VII).

In most cases, results for the three Method 26A samples at individual locations are consistent. Run 1 at Location 2 appears to have significantly lower concentrations of both fluoride and chloride than the other runs at this location. Likewise, Run 3 at Location 10 also appears to have lower fluoride and chloride concentrations than other runs at this location. The results for chloride at the Baghouse Inlet (Location 5) may be suppressed due to the presence of lime in the gas stream (the particulate phase is not analyzed in Method 26A).

TABLE III-25. CHLORIDE/FLUORIDE RESULTS FOR METHOD 26A SAMPLE

Sampling Location	Sample I.D.	Sample Volume (dscm)	F- (µg/dscm)	Cl- (µg/dscm)
Location 2 - SNRB Inlet	R1-L2	2.28	204	9060
	R2-L2	2.33	2870	46000
	R3-L2	2.06	5960	36300
	Average	2.23	3010	30400
Location 5 - Baghouse Inlet	R1-L5	2.11	ND<2.40	527
	R2-L5	1.76	55.90	1300
	R3-L5	3.19	2.51	1160
	Average	2.36	19.87	996
Location 7 - SNRB Outlet	R1-L7	2.11	73.00	889
	R2-L7	2.23	ND<2.42	1060
	R3-L7	2.06	42.20	332
	Average	2.13	38.80	760
Location 10 - ESP Inlet	R1-L10	1.64	3400	25500
	R2-L10	1.82	7250	35300
	R3-L10	1.64	1380	5350
	Average	1.70	4010	22000
Location 12 - ESP Outlet	R1-L12	2.96	4780	35500
	R2-L12	2.98	6700	39400
	R3-L12	2.86	7180	35900
	Average	2.94	6220	36900
Field Blank*	Location 7	2.83	5.62	356
Field Blank*	Location 12	2.83	ND<1.52	304
H2SO4 Blank*	--	2.83	ND<0.63	ND<63.2
H2O Blank*	--	2.83	ND<0.75	ND<0.75

*Blank results calculated using average gas sample volume from all runs.

(QPro Filename: CHLFLO.WB1)

TABLE III-26 . CHLORIDE/FLUORIDE RESULTS FOR SOLID SAMPLES

Sampling Location	Sample I.D.	F- (µg/g)	Cl- (µg/g)
Location 1 - Coal Feed***	R1-L1	60	340
	R2-L1	70	410
	R3-L1	80	370
	Average	70	373
Location 3 - Sorbent Feed	R1-L3	3.4	<10**
	R1-L3	3.9	<10**
	R1-L3	3.3	<10**
	Average	3.5	<10**
Location 6 - SNRB Solids	R1-L6	20	740
	R2-L6	21	960
	R3-L6	29	830
	Average	23	843
Location 8 - Bottom Ash	R1-L8	<0.10*	0.66
	R2-L8	<0.10	2.2
	R3-L8	<0.10	2.7
	Average	<0.10	1.9
Location 9 - Economizer Ash	R1-L9	0.47	0.57
	R2-L9	0.26	0.67
	R3-L9	0.23	0.28
	Average	0.32	0.51
Location 11 - Collected Flyash	R1-L11	6.8	5.5
	R2-L11	7.6	4.3
	R3-L11	6.7	3.5
	Average	7.0	4.4

*"<" indicates analyte not detected; number represents detection limit.
**Detection limit for chloride in sorbent feed is high (10 µg/g) due to matrix interference.
***Analyses conducted by CTE.

(QPro Filename: CFLSOL.WB1)

G. Polynuclear Aromatic Hydrocarbons

The concentration of PAH detected in gas emissions collected with a Method 23 train are presented in Table III-27 for field and QC samples. PAH data were treated as follows:

- Sample results were not corrected for Location 7 or Location 12 Method 23 train blanks, the laboratory method blank, or matrix spike results.

- Train blank concentrations were calculated using a nominal 3 dscm as the gas sample volume.

- Averages were calculated by averaging results for the number of runs which had concentrations above the method detection limit. If an analyte was detected in all three runs, the average across the three runs was determined. If an analyte was not detected in one or two of the three runs, the average was determined using half of the detection limit for those runs in which the analyte was not detected; if the average was less than the highest detection limit, the result is reported as ND< (highest detection limit). In cases where an analyte was not detected in all three runs, the average was calculated as the average of the three detection limits.

- The detection limit was determined by comparing the instrument noise level in the absence of a peak to the response of a known amount of internal standard.

The Run 3 sample from Location 2 (SNRB™ Inlet) could not be analyzed due to significant organic loading in the sample extract even after column cleanup. Therefore, data are not included in Table III-27 for this sample. As noted in Section VII (Data Evaluation), some samples had low internal standard recoveries possibly due to the high particulate loading which impeded extraction efficiency. These samples are identified in Table III-27.

PAH results for triplicate runs at each location are consistent within a factor of approximately 10 or less. PAH emissions do not appear to be significantly different between inlet and outlet locations (i.e., SNRB™ Inlet - Location 2 vs SNRB™ Outlet - Location 7; ESP Inlet - Location 10 vs ESP Outlet - Location 12). For some compounds, PAH

TABLE III-27. RESULTS FOR PAH ANALYSES OF METHOD 23 SAMPLES (ng/dcsm)

Compound	Method Blank*	Matrix Spike*	Field BLK* L7	Field BLK* L12	Location 2 - SNRB™ Inlet R1-L2	R2-L2	Average
Naphthalene	5.00	92.33	274.67	196.00	377.85	185.49	281.67
2-Methylnaphthalene	6.67	8.67	15.00	14.33	87.69	58.55	73.12
1-Methylnaphthalene	2.67	3.00	6.00	5.67	35.69	25.91	30.80
Biphenyl	3.00	3.67	4.33	5.67	59.08	18.13	38.61
Acenaphthylene	ND< 0.002	ND< 0.002	ND< 0.002	ND< 0.002	6.46	3.63	5.04
Acenaphthene	2.33	5.00	2.33	9.67	40.62	23.32	31.97
Fluorene	3.67	5.67	3.67	12.33	158.46	39.38	98.92
Phenanthrene	9.00	15.67	18.00	55.67	63.69	134.20	98.94
Anthracene	0.67	1.00	0.67	2.33	9.23	29.53	19.38
Fluoranthene	3.33	6.00	4.33	17.33	24.00	10.36	17.18
Pyrene	2.00	4.33	1.67	13.00	10.46	7.25	8.86
Benzo[a]anthracene	0.33	0.67	1.33	7.00	4.31	2.07	3.19
Chrysene	0.67	1.33	1.33	7.00	11.08	4.15	7.61
Benzofluoranthenes	1.33	1.67	2.33	10.67	3.38	9.84	6.61
Benzo[e]pyrene	0.33	0.33	0.33	3.33	6.15	5.70	5.93
Benzo[a]pyrene	ND< 0.005	0.67	1.33	7.33	5.23	3.11	4.17
Indeno[1,2,3-c,d]pyrene	ND< 0.007	0.67	1.33	3.00	6.15	2.07	4.11
Dibenzo[a,h]anthracene	ND< 0.008	1.33	1.33	5.00	12.62	2.59	7.60
Benzo[g,h,i]perylene	ND< 0.006	0.33	0.67	3.00	7.69	2.59	5.14

Matrix Spike is laboratory QC sample spiked with dioxin/furans for dioxin/furan accuracy determination but which serves as a second method blank for PAH analyses (see page VII-57).

*Results for QC samples calculated using 3 dscm gas sample volume.

**Recovery of spike compounds 11 to 37 percent.

TABLE III-27. RESULTS FOR PAH ANALYSES OF METHOD 23 SAMPLES (ng/dcsm) (continued)

	Location 5 - Baghouse Inlet				Location 7 - SNRB™ Outlet			
Compound	R1-L5	R2-L5**	R3-L5	Average	R1-L7	R2-L7	R3-L7	Average
Naphthalene	487.19	415.17	12.88	305.08	159.24	516.24	540.05	405.18
2-Methylnaphthalene	3511.98	78.09	6.30	1198.79	12.41	49.75	23.53	28.56
1-Methylnaphthalene	1989.69	38.76	1.92	676.79	5.82	25.38	9.95	13.72
Biphenyl	35.10	25.84	3.01	21.32	9.37	21.32	14.93	15.21
Acenaphthylene	274.65	2.25	0.55	92.48	1.27	3.05	2.94	2.42
Acenaphthene	33.98	28.09	6.58	22.88	1.77	29.95	6.79	12.84
Fluorene	54.60	28.09	9.32	30.67	35.70	52.79	111.31	66.60
Phenanthrene	142.34	90.45	51.78	94.86	50.13	316.75	97.96	154.95
Anthracene	33.43	5.06	2.74	13.74	8.61	14.72	4.75	9.36
Fluoranthene	56.27	33.71	22.74	37.57	16.96	154.82	41.40	71.06
Pyrene	30.64	17.42	9.86	19.31	9.37	64.97	14.48	29.61
Benzo[a]anthracene	5.57	2.81	2.74	3.71	10.89	9.64	5.43	8.65
Chrysene	6.69	5.06	4.11	5.28	16.96	14.21	16.29	15.82
Benzofluoranthenes	8.36	8.43	5.21	7.33	24.30	27.92	15.38	22.54
Benzo[e]pyrene	11.70	3.93	2.19	5.94	10.38	12.18	2.94	8.50
Benzo[a]pyrene	5.29	1.12	3.01	3.14	15.70	10.15	10.41	12.09
Indeno[1,2,3-c,d]pyrene	8.91	1.12	4.38	4.81	15.70	11.17	5.43	10.76
Dibenzo[a,h]anthracene	14.76	1.12	6.03	7.30	19.49	5.58	3.39	9.49
Benzo[g,h,i]perylene	9.19	0.56	4.11	4.62	18.23	12.18	5.20	11.87

*Results for QC samples calculated using 3 dscm gas sample volume.
**Recovery of spike compounds 11 to 37 percent.

TABLE III-27. RESULTS FOR PAH ANALYSES OF METHOD 23 SAMPLES (ng/dcsm) (continued)

Compound	Location 10 - ESP Inlet				Location 12 - ESP Outlet			
	R1-L10**	R2-L10**	R3-L10**	Average**	R1-L12	R2-L12	R3-L12	Average
Naphthalene	37.95	481.23	7.00	175.39	95.05	32.32	93.08	73.48
2-Methylnaphthalene	10.89	129.12	5.32	48.44	16.10	13.72	13.52	14.45
1-Methylnaphthalene	5.61	53.26	2.24	20.37	7.12	5.18	5.03	5.78
Biphenyl	6.93	28.35	3.08	12.79	6.81	6.10	5.66	6.19
Acenaphthylene	4.62	4.21	8.96	5.93	1.86	2.13	6.92	3.64
Acenaphthene	1.65	102.30	2.52	35.49	6.19	18.29	8.49	10.99
Fluorene	89.44	55.94	14.29	53.22	26.63	19.82	20.13	22.19
Phenanthrene	73.93	108.81	45.10	75.95	92.57	89.02	230.19	137.26
Anthracene	9.90	4.98	4.20	6.36	8.36	6.10	10.69	8.38
Fluoranthene	22.11	25.29	12.61	20.00	81.11	48.78	105.35	78.41
Pyrene	9.90	9.20	5.04	8.05	37.46	25.30	48.11	36.96
Benzo[a]anthracene	2.64	2.68	0.56	1.96	3.41	18.60	23.58	15.20
Chrysene	5.94	2.30	3.92	4.05	6.50	24.09	116.67	49.08
Benzofluoranthenes	8.58	14.94	3.08	8.87	10.84	34.45	23.58	22.96
Benzo[e]pyrene	9.57	2.30	2.52	4.80	7.43	11.59	7.23	8.75
Benzo[a]pyrene	10.89	2.68	2.24	5.27	42.41	18.29	8.18	22.96
Indeno[1,2,3-c,d]pyrene	7.26	1.92	2.52	3.90	6.81	17.38	6.60	10.26
Dibenzo[a,h]anthracene	7.26	1.15	1.40	3.27	4.64	8.84	7.23	6.91
Benzo[g,h,i]perylene	10.56	1.92	0.84	4.44	6.81	14.02	9.75	10.19

* Results for QC samples calculated using 3 dscm gas sample volume.

** Recovery of spike compounds 11-37 percent.

emissions do not appear to be higher than PAH levels detected in field blank samples. PAH levels in laboratory method blanks are lower than field blank samples.

H. Dioxins/Furans

The concentration of dioxins/furans in gas emissions collected with a Method 23 train are presented in Table III-28. Complete data reporting forms showing internal standard recoveries are included in Appendix B. As noted in Section VII (Data Evaluation), two samples from Location 5 (Baghouse Inlet) and two samples from Location 10 (ESP Inlet) had extremely low internal standard recoveries most likely due to the high particulate loading which impeded efficient Soxhlet extraction. Results for these samples are included in Table III-28 but should be considered suspect. Dioxin/furan data were treated as follows:

- Sample results were not corrected for Location 7 or Location 12 Method 23 train blanks or method blank results. Blank results were calculated using 2 dscm gas sample volume.

- The detection limit was determined by comparing the instrument noise level in the absence of a peak to the response of a known amount of internal standard.

- Train blank concentrations were calculated using the average gas sample volume from the three runs at the associated location.

- Averages were calculated by averaging results for the number of runs which had concentrations above the method detection limit and acceptable recoveries. If an analyte was detected in all three runs, the average across the three runs was determined. If an analyte was not detected in one or two of the three runs, the average was determined using half of the detection limit for those runs in which the analyte was not detected; if the average was less than the highest detection limit, the result is reported as ND< (highest detection limit). In cases where an analyte was not detected in all three runs, the average was calculated as the average of the three detection limits.

Tetra- through octa-CDF were found in most Method 23 samples. 2,3,7,8-TCDF was found in all samples except Run 3 from Location 12 (ESP Outlet) and Run 2 from Location 5 (Baghouse Inlet). Of the dioxins, only the higher chlorinated compounds (hexa- through octa-CDD) were detected in most samples. The concentration of octa-CDD in most samples was only slightly higher than the level detected in the laboratory method

TABLE III-28. RESULTS FOR DIOXIN/FURAN ANALYSES OF METHOD 23 SAMPLES (pg/dscm)

ANALYTE	Method Blank	L7 Field Blank	L12 Field Blank	Location 5 - Baghouse Inlet R1-L5*	R2-L5*	R3-L5	Average**	Location 7 - SNRB Outlet R1-L7	R2-L7	R3-L7	Average
2378-TCDD	ND< 4.5	ND< 1.9	ND< 2.7	151	ND< 60.0	ND< 5.1	ND< 5.1	ND< 1.1	4.0	ND< 1.7	1.8
12378-PeCDD	ND< 1.8	ND< 1.1	ND< 6.6	1385	ND< 75.7	ND< 1.2	ND< 1.2	ND< 2.1	50	ND< 2.2	17.3
123478-HxCDD	ND< 2.4	ND< 0.9	ND< 8.6	5383	ND< 275.2	ND< 2.8	ND< 2.8	ND< 1.5	119	ND< 2.6	40.4
123678-HxCDD	ND< 1.4	ND< 0.8	ND< 5.7	1132	ND< 107.2	2.9	2.9	ND< 2.5	128	ND< 2.3	43.4
123789-HxCDD	ND< 5.7	ND< 2.4	ND< 16.3	3175	ND< 147.7	3.7	3.7	1.8	261	ND< 3.4	88.1
1234678-HpCDD	ND< 10.0	ND< 12.1	ND< 15.0	14458	529.3	29.7	29.7	ND< 14.2	1547	8.5	520.8
OCDD	69.2	49.9	47.0	200947	5476.9	81.5	81.5	37.4	4171	32.3	1413.7
2378-TCDF	ND< 1.9	ND< 1.5	ND< 1.8	4818	ND< 82.2	1.9	1.9	3.0	116	2.6	40.5
12378-PeCDF	ND< 3.1	ND< 1.3	ND< 15.3	3907	ND< 148.6	ND< 3.3	ND< 3.3	ND< 4.9	95	ND< 2.4	32.9
23478-PeCDF	ND< 2.3	ND< 1.3	ND< 2.9	5126	ND< 114.6	1.8	1.8	1.9	179	1.4	60.9
123478-HxCDF	ND< 36.5	ND< 7.3	ND< 359.9	100960	ND< 759.3	5.5	5.5	9.7***	3016***	3.4	3.4**
123678-HxCDF	ND< 17.4	ND< 4.1	ND< 423.8	16445	ND< 433.6	3.0	3.0	ND< 7.6***	461***	1.1	1.1**
123789-HxCDF	ND< 10.0	2.6	ND< 6.9	25404	155.0	6.5	6.5	3.4	646	2.3	217.2
234678-HxCDF	ND< 2.1	ND< 1.5	ND< 1.2	2050	ND< 227.0	ND< 2.3	ND< 2.3	ND< 1.2	40	ND< 1.8	13.9
1234678-HpCDF	ND< 19.7	ND< 24.2	ND< 2159.0	185056	ND< 11055.1	ND< 68.2	ND< 68.2	ND< 61.0	3407	ND< 80.9	1159.3
1234789-HpCDF	ND< 3.0	ND< 1.3	ND< 4.6	28257	258.9	7.5	7.5	ND< 3.7	461	1.7	154.7
OCDF	ND< 11.3	3.7	ND< 3.2	107067	911.9	22.2	22.2	7.6	2057	7.4	690.6
Total TCDD	ND< 4.5	ND< 1.9	ND< 2.7	1346	ND< 60.0	ND< 5.1	ND< 5.1	ND< 1.1	30	ND< 1.7	10.4
Total PeCDD	ND< 1.8	ND< 1.1	ND< 6.6	7224	ND< 75.7	ND< 1.2	ND< 1.2	ND< 2.1	185	ND< 2.2	62.3
Total HxCDD	ND< 2.4	ND< 0.9	ND< 8.6	14704	137.7	14.4	14.4	1.8	960	ND< 2.6	321.2
Total HpCDD	ND< 10.0	ND< 12.1	ND< 15.0	26321	915.7	47.1	47.1	ND< 14.2	2721	14.1	914.1
Total TCDF	ND< 1.9	6.4	ND< 1.8	10040	122.1	10.1	10.1	12.7	245	11.7	90.0
Total PeCDF	ND< 3.1	ND< 1.3	ND< 15.3	33950	ND< 148.6	13.7	13.7	1.9	828	2.7	277.7
Total HxCDF	ND< 36.5	2.6	ND< 359.9	305976	155.0	19.5	19.5	13.0	6881	6.8	2300.4
Total HpCDF	ND< 19.7	ND< 24.2	ND< 2159.0	252938	258.9	22.0	22.0	ND< 61.0	4687	4.2	1573.8

*Indicates recovery for all internal standards in sample are less than 50 percent.
**Average does not include samples with unacceptable recoveries.
***Indicates recovery for individual internal standard is less than 50 percent.
(QPro Filename: DIOXIN.WB1)

TABLE III-28. RESULTS FOR DIOXIN/FURAN ANALYSES OF METHOD 23 SAMPLES (pg/dscm) (continued)

ANALYTE	Location 10 - ESP Inlet								Location 12 - ESP Outlet							
		R1-L10*		R2-L10*		R3-L10		Average**		R1-L12		R2-L12		R3-L12		Average
2378-TCDD	ND<	29	ND<	18.8	ND<	2.6	ND<	2.6	ND<	1.7		9.9	ND<	2.1		3.9
12378-PeCDD		32	ND<	11.9	ND<	1.7	ND<	1.7	ND<	1.5	ND<	0.8	ND<	3.8	ND<	2.0
123478-HxCDD		68	ND<	31.6	ND<	3.8	ND<	3.8	ND<	4.2	ND<	2.6	ND<	2.4	ND<	3.1
123678-HxCDD		96	ND<	62.1	ND<	11.4	ND<	11.4	ND<	3.4	ND<	2.2	ND<	2.1	ND<	2.6
123789-HxCDD		148		40.7	ND<	8.1	ND<	8.1		3.3	ND<	5.1	ND<	3.4	ND<	5.1
1234678-HpCDD		1110		363.2		27.4		27.4		10.7		11.7		9.5		10.6
OCDD		6753		1665.9		79.1		79.1		62.7		85.0		68.8		72.2
2378-TCDF		61		8.4		1.9		1.9		2.0		1.6	ND<	2.4	ND<	2.4
12378-PeCDF		53	ND<	42.3	ND<	2.5	ND<	2.5	ND<	3.8	ND<	2.3	ND<	1.5	ND<	2.5
23478-PeCDF		67		12.6	ND<	4.5	ND<	4.5	ND<	5.2	ND<	2.8	ND<	1.9	ND<	3.3
123478-HxCDF		1258	ND<	271.9		4.3		4.3		17.5***		4.2	ND<	5.9	ND<	5.9**
123678-HxCDF	ND<	392	ND<	128.1		2.5		2.5		5.8***		1.7		1.3		1.5**
123789-HxCDF		173		27.2		3.9		3.9		5.0		4.3		3.3		4.2
234678-HxCDF		47	ND<	32.1	ND<	2.6	ND<	2.6	ND<	1.9	ND<	1.2	ND<	2.4	ND<	1.8
1234678-HpCDF	ND<	5725	ND<	5219.0	ND<	51.3	ND<	51.3	ND<	112.8	ND<	75.5	ND<	117.3	ND<	101.9
1234789-HpCDF		334		92.3		6.2		6.2	ND<	9.2		3.4		2.9	ND<	9.2
OCDF		1854		304.9		16.0		16.0		22.2		29.8		19.0		23.6
Total TCDD	ND<	29	ND<	18.8	ND<	2.6	ND<	2.6	ND<	1.7		9.9	ND<	2.1		3.9
Total PeCDD		73	ND<	11.9	ND<	1.7	ND<	1.7	ND<	1.5		8.2	ND<	3.8	ND<	3.8
Total HxCDD		549		112.1	ND<	3.8	ND<	3.8		6.8	ND<	2.6	ND<	2.4		3.1
Total HpCDD		1900		598.2		46.0		46.0		19.2		20.1		16.7		18.7
Total TCDF		184		41.0		11.4		11.4		10.3		10.7		2.3		7.8
Total PeCDF		333		55.1	ND<	2.5	ND<	2.5	ND<	3.8		2.0	ND<	1.5	ND<	3.8
Total HxCDF		3612		27.2		10.7		10.7		28.3		18.3		6.2		17.6
Total HpCDF		334		190.2		16.0		16.0		7.0		13.0		10.6		10.2

*Indicates recovery for all internal standards in sample are less than 50 percent.
**Average does not include samples with unacceptable recoveries.
***Indicates recovery for individual internal standard is less than 50 percent.
(QPro Filename: DIOXIN.WB1)

blank or the field blanks which is not surprising since octa-CDD is ubiquitous in the environment. The solvent specified in Method 23 for extraction was not used for these analyses because of the need to analyze these same samples for PAH. However, the solvent used -- methylene chloride -- has demonstrated excellent recoveries for dioxin/furans in recent work conducted by Battelle. Some of the low recoveries obtained for these samples are attributed to the large amount of particulate which may have impeded extraction efficiency.

The dioxin/furan concentrations in the emission samples collected in Run 2 from Location 7 (SNRB™ Outlet) are significantly higher than the concentrations detected in the samples from Runs 1 and 3 at this same location. The cause for these higher Run 2 concentrations is unknown. Results for Location 12 (ESP Outlet) are mostly consistent across the three runs, with the exception of 2,3,7,8-TCDD which was detected in Run 2 at a concentration of 9.9 pg/dscm and not detected in the other two runs (detection limit of approximately 2 pg/dscm).

I. Carbonyls

Results for the carbonyl analyses of Method 0011 train flue gas samples are presented in Table III-29. As shown, carbonyl compounds were not detected in any of the flue gas samples, although the detection limit achieved in these analyses met the target detection limit of 1.4 μg/dscm. Note that the solutions from the two DNPH impingers were analyzed separately to check for breakthrough. The probe and cyclone rinse and the solution from the third impinger in the Method 0011 train were not analyzed for carbonyls.

In contrast to the flue gas samples, the field blanks and the DNPH reagent blank showed a trace amount of acetone. This result suggests that DNPH derivatives in the flue gas samples should have been present (at least for acetone) but may have been destroyed through the sampling or analysis process. The high SO_2 concentration in the gas emissions may have contributed to losses because it is a strong oxidant, although prior to field sampling, the U.S. EPA was consulted and indicated that high SO_2 was not a concern. Likewise, the DNPH derivatives may have adsorbed to the unexpected, large amount of particulate matter in the DNPH impinger solutions, and therefore been removed from

TABLE III-29. RESULTS FOR CARBONYL ANALYSES, (µg/dscm)

Analyte	Location 2 - SNRB Inlet		Location 5 - Baghouse Inlet		Location 7 - SNRB Outlet					
	Run 1		Run 1		Field Blank		Run 1		Run 2	
	Imp #1 R1-L2	Imp #2 R1-L2	Imp #1 R1-L5	Imp #2 R1-L5	Imp #1 Field BLK	Imp #2 Field BLK	Imp #1 R1-L7	Imp #2 R1-L7	Imp #1 R2-L7	Imp #2 R2-L7
Formaldehyde	<0.03	<0.04	<0.03	<0.04	<0.13	<0.12	<0.07	<0.07	<0.08	<0.12
Acetaldehyde	<0.03	<0.03	<0.03	<0.03	0.24	<0.12	<0.06	<0.06	<0.08	<0.11
Acrolein	<0.04	<0.05	<0.04	<0.05	<0.18	<0.17	<0.09	<0.09	<0.11	<0.16
Acetone	<0.04	<0.05	<0.04	<0.05	2.29	2.51	<0.09	<0.09	<0.12	1.07
Propionaldehyde	<0.04	<0.05	<0.05	<0.05	<0.20	<0.19	<0.10	<0.10	<0.13	<0.17
Crotonaldehyde	<0.05	<0.06	<0.05	<0.06	<0.23	<0.21	<0.11	<0.11	<0.14	<0.20
Butyraldehyde	<0.06	<0.07	<0.06	<0.07	<0.26	<0.24	<0.13	<0.13	<0.16	<0.22
Benzaldehyde	<0.09	<0.10	<0.09	<0.10	<0.38	<0.35	<0.19	<0.19	<0.24	<0.33

Analyte	Location 10 - ESP Inlet				Location 12 - ESP Outlet						
	Run 1		Run 2		Field Blank		Run 1			Run 2	
	Imp #1 R1-L10	Imp #2 R1-L10	Imp #1 R2-L10	Imp #2 R2-L10	Imp #1 Field BLK	Imp #2 Field BLK	Imp #1 R1-L12	Imp #1 U R1-L12	Imp #2 R1-L12	Imp #1 R2-L12	Imp #2 R2-L12
Formaldehyde	<0.04	<0.05	<0.04	NA	<0.11	<0.11	<0.02	<0.07	<0.02	<0.05	<0.05
Acetaldehyde	<0.04	<0.05	<0.04	NA	<0.10	<0.10	<0.02	<0.07	<0.02	<0.05	<0.05
Acrolein	<0.06	<0.07	<0.05	NA	<0.15	<0.15	<0.02	<0.10	<0.03	<0.07	<0.07
Acetone	<0.06	<0.07	<0.05	NA	2.37	1.75	<0.02	<0.10	<0.03	0.09	<0.07
Propionaldehyde	<0.06	<0.07	<0.06	NA	<0.16	<0.16	<0.03	<0.11	<0.03	<0.07	<0.07
Crotonaldehyde	<0.07	<0.08	<0.06	NA	<0.18	<0.18	<0.03	<0.12	<0.03	<0.08	<0.08
Butyraldehyde	<0.08	<0.09	<0.07	NA	<0.20	<0.20	<0.03	<0.13	<0.09	<0.09	<0.09
Benzaldehyde	<0.12	<0.14	<0.11	NA	<0.30	<0.30	<0.05	<0.20	<0.05	<0.14	<0.14

Analyte	DNPH Blank	Methylene Chloride Blank	DI Water Blank
Formaldehyde	<0.13	<0.13	<0.13
Acetaldehyde	<0.12	<0.12	<0.12
Acrolein	<0.18	<0.18	<0.18
Acetone	2.06	<0.19	<0.19
Propionaldehyde	<0.19	<0.19	<0.19
Crotonaldehyde	<0.22	<0.22	<0.22
Butyraldehyde	<0.25	<0.25	<0.25
Benzaldehyde	<0.37	<0.37	<0.37

NA = Sample results not available.

solution. Standard Method 0011 analysis procedures detail a methylene chloride extraction of the sample although those analysis procedures were not incorporated into the analytical plan for this project. Acetonitrile was used to prepare the impinger DNPH solution and methylene chloride was used by EER to recover the samples. These two solvents do not mix so the methylene chloride layer from the Impinger 1 sample collected on April 26 at Location 12 was analyzed to determine if the DNPH derivatives had preferentially partitioned into this solvent. Carbonyls were not detected in this methylene chloride layer (reported as Imp #1 U in Table III-29). Any further investigation of these samples was not conducted.

J. Volatile Organic Compounds

Tedlar bag samples were collected on April 29, 1993 but upon receipt at Battelle these samples appeared to have leaked and were not analyzed. Consequently, two Tedlar bag samples (representing Runs 1 and 2) were collected at each gas sampling location (except Location 12 where only one sample was collected) on April 30, and one Tedlar bag sample (representing Run 3) was collected at each of Locations 2, 5, and 7 (SNRB™ Inlet, Baghouse Inlet, and SNRB™ Outlet) on May 1.

Results from the VOC analysis of the Method 18 Tedlar bag samples are provided in Table III-30. As indicated in Table III-30, VOC data were treated as follows:

- Results for the trip blank were not subtracted from sample results.
- Averages were calculated by averaging results for the number of runs that had concentrations above the method detection limit. If an analyte was detected in all three runs, the average across the three runs was determined. If an analyte was not detected in one or two of the three runs, the average was determined using half of the detection limit for those runs in which the analyte was not detected; if the average was less than the highest detection limit, the result is reported as ND< (highest detection limit). In cases where an analyte was not detected in all three runs, the average was calculated as the average of the three detection limits.
- Averages were not calculated for analytes in which the field spike recoveries were less than 80 percent (see Table VII-43). These data should be considered suspect. An exception is toluene for which the field spike recovery was 77 percent.

TABLE III-30. RESULTS FOR VOC ANALYSES (ppb)

Analyte	Trip Blank**	Location 2 - SNRB Inlet 4/30/93 R1-L2	Location 2 - SNRB Inlet 4/30/93 R2-L2	Location 2 - SNRB Inlet 5/01/93 R3-L2	Average Location 2	Location 5 - Baghouse Inlet 4/30/93 R1-L5	Location 5 - Baghouse Inlet 4/30/93 R2-L5	Location 5 - Baghouse Inlet 5/01/93 R3-L5	Average Location 5
trichlorofluoromethane (Freon-11)	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	0.7	ND< 0.5	ND< 0.5
1,1-dichloroethene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
dichloromethane	197.8	97.8	120.3	53.5	90.6	218.6	130.5	212.3	187.1
3-chloropropene	2.0	ND< 0.5	2.7	ND< 0.5	1.1	2.8	1.7	3.2	2.6
1,1,2-trichloro-1,2,2-trifluoroethan	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
1,1-dichloroethane	0.4#	1.1	1.5	1.3	1.3	1.0	0.6	6.1	2.8
cis-1,2-dichloroethene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
trichloromethane	ND< 0.5	ND< 0.5	1.1	1.6	1.0	3.9	1.3	0.9	2.1
1,2-dichloroethane	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
1,1,1-trichloroethane	0.2#	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	0.6	ND< 0.5
benzene	3.1	6.3	9.6	5.0	7.0	1.7	6.4	10.5	6.2
carbon tetrachloride	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	1.1	0.6	0.6
1,2-dichloropropane	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
trichloroethene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
cis-1,3-dichloropropene	1.2	1.4	1.7	5.5	2.9	6.4	2.4	3.6	4.2
trans-1,3-dichloropropene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	2.0	1.7	ND< 0.5	1.3
1,1,2-trichloroethane	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
toluene*	3.9	2.4	3.0	1.3	2.2	4.3	3.1	16.8	8.1
1,2-dibromoethane	ND< 0.5	3.0	1.0	ND< 0.5	1.4	ND< 0.5	0.9	ND< 0.5	ND< 0.5
tetrachloroethene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
chlorobenzene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
ethylbenzene*	1.5	0.6	5.6	0.6	NC***	4.6	7.8	1.9	NC
m+p-xylene	1.7	0.6	2.0	0.7	1.1	5.2	4.9	1.4	3.8
styrene*	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	NC	ND< 0.5	8.6	ND< 0.5	NC
1,1,2,2-tetrachloroethane *	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	NC	ND< 0.5	ND< 0.5	ND< 0.5	NC
o-xylene*	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	NC	ND< 0.5	ND< 0.5	0.7	NC
4-ethyl toluene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	1.7	ND< 0.5	2.0	1.3
1,3,5-trimethylbenzene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	1.8	ND< 0.5	2.0	1.3
1,2,4-trimethylbenzene	14.7	7.1	5.8	37.6	16.8	28.4	20.1	6.6	18.4
benzyl chloride *	ND< 0.5	ND< 0.5	6.9	6.5	NC	7.2	6.9	ND< 0.5	NC
m-dichlorobenzene*	4.6	2.5	12.1	10.7	NC	13.8	15.4	1.7	NC
p-dichlorobenzene	5.9	3.6	17.0	15.1	11.9	19.5	21.8	2.5	14.6
o-dichlorobenzene*	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
1,2,4-trichlorobenzene*	9.0	4.9	38.6	1.7	NC	38.8	49.2	3.2	NC
hexachlorobutadiene*	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5

*Recoveries for analyte in field spike are less than 80 percent.
**Sample results are not corrected for trip blank.
***NC = Average not calculated since spike recovery does not meet objective.
#Analyte detected below method detection limit of .5 ppb.

(Vanessa QPRO Table Disk: VOCDATA)

TABLE III-30. RESULTS FOR VOC ANALYSES (ppb) (continued)

Analyte	Location 7 - SNRB Outlet 4/30/93 R1-L7	Location 7 - SNRB Outlet 4/30/93 R2-L7	Location 7 - SNRB Outlet 5/01/93 R3-L7	Average Location 7	Location 10 ESP Inlet 4/30/93 R1-L10	Location 10 ESP Inlet 4/30/93 R2-L10	Average Location 10	Location 12 ESP Outlet 4/30/93 R1-L12
trichlorofluoromethane (Freon-11)	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
1,1-dichloroethene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
dichloromethane	138.3	132.0	544.1	271.5	278.3	181.8	230.0	132.3
3-chloropropene	2.9	1.0	8.6	4.2	0.6	1.7	1.2	5.4
1,1,2-trichloro-1,2,2-trifluoroethane	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
1,1-dichloroethane	0.6	0.8	ND< 0.5	0.5	4.7	3.5	4.1	3.2
cis-1,2-dichloroethene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	1.9	1.1	ND< 0.5
trichloromethane	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	3.0	3.4	3.2	1.8
1,2-dichloroethane	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
1,1,1-trichloroethane	ND< 0.5	ND< 0.5	1.0	0.5	1.0	1.2	1.1	0.9
benzene	6.3	4.5	4.9	5.3	11.4	14.9	13.1	12.1
carbon tetrachloride	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	0.5	0.7	0.6	ND< 0.5
1,2-dichloropropane	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
trichloroethene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
cis-1,3-dichloropropene	0.8	0.9	1.9	1.2	3.4	11.4	7.4	2.8
trans-1,3-dichloropropene	1.1	ND< 0.5	ND< 0.5	0.5	1.3	ND< 0.5	0.8	ND< 0.5
1,1,2-trichloroethane	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
toluene*	3.3	2.5	4.0	3.2	8.2	12.1	10.1	2.5
1,2-dibromoethane	1.3	ND< 0.5	ND< 0.5	0.6	ND< 0.5	0.7	ND< 0.5	1.1
tetrachloroethene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
chlorobenzene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	0.8	0.6	0.7	ND< 0.5
ethylbenzene*	7.4	0.9	0.6	NC	3.5	7.5	NC	8.9
m+p-xylene	6.9	0.9	1.1	3.0	12.1	11.5	11.8	2.8
styrene*	3.8	ND< 0.5	ND< 0.5	NC	ND< 0.5	ND< 0.5	NC	ND< 0.5
1,1,2,2-tetrachloroethane *	ND< 0.5	ND< 0.5	ND< 0.5	NC	ND< 0.5	ND< 0.5	NC	ND< 0.5
o-xylene*	ND< 0.5	ND< 0.5	ND< 0.5	NC	0.6	1.4	NC	0.8
4-ethyl toluene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	1.5	2.2	1.8	1.4
1,3,5-trimethylbenzene	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	1.5	2.2	1.9	1.4
1,2,4-trimethylbenzene	8.4	1.1	ND< 0.5	3.3	58.5	0.5	29.5	0.5
benzyl chloride *	10.1	ND< 0.5	ND< 0.5	NC	11.5	36.7	NC	23.8
m-dichlorobenzene*	13.4	ND< 0.5	ND< 0.5	NC	23.3	67.5	NC	52.1
p-dichlorobenzene	18.6	ND< 0.5	ND< 0.5	6.4	32.9	94.9	63.9	73.4
o-dichlorobenzene*	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5
1,2,4-trichlorobenzene*	41.1	ND< 0.5	ND< 0.5	NC	61.2	59.6	NC	43.3
hexachlorobutadiene*	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5	ND< 0.5

*Recoveries for analyte in field spike are less than 80 percent.
**Sample results are not corrected for trip blank.
***NC = Average not calculated since spike recovery does not meet objective.
#Analyte detected below method detection limit of .5 ppb.

Of the VOC compounds analyzed, the following compounds were detected in most Tedlar bag samples:

dichloromethane
3-chloropropene
1,1-dichloroethane
trichloromethane
benzene
cis-1,3-dichloropropene
toluene
ethylbenzene
m,p-xylene
1,2,4-trimethylbenzene
benzyl chloride
m-dichlorobenzene
p-dichlorobenzene
1,2,4-trichlorobenzene

Of these detected VOC compounds, concentrations for benzene, cis-1,3-dichloropropene, m-dichlorobenzene, p-dichlorobenzene, and 1,2,4-trichlorobenzene appear to be higher than concentrations in the Tedlar bag trip blank processed with these analyses. For other detected VOC compounds, concentrations are relatively equivalent to the trip blank concentrations for most samples. While Tedlar bag samples were collected at some locations under high vacuum conditions, modifications to the sampling system were made in the field to accommodate these conditions; therefore, impact on the sampling was expected to be minimal.

K. Radionuclides

Results from the radionuclide analysis of coal and filters from Method 26A (Locations 2, 7, 10, and 12) and Method 5 (Location 5) samples are presented in Table III-31. These analyses were conducted by International Technology Corporation (IT). The complete data package for these analyses, including error associated with analytical results, is provided in Appendix C. The following should be noted for these analyses:

- Th^{232} and Th^{228} when analyzed by gamma spectrometry are reported as R^{228}. P^{210} when analyzed by gamma spectrometry is reported as Pb^{210}. This is based on the assumption that thorium and radium, and polonium and lead, are in secular equilibrium.

TABLE III-31. RADIONUCLIDE RESULTS FOR SOLID AND GAS SAMPLES (a)

ANALYTE	COAL FEED LOCATION 1			SNRB INLET LOCATION 2			BAGHOUSE INLET LOCATION 5			SNRB OUTLET LOCATION 7		
	RUN 1	RUN 2	RUN 3	RUN 1	RUN 2	RUN 3	RUN 1	RUN 2	RUN 3	RUN 1	RUN 2	RUN 3
PB-210	0.437	<.43	<.50	<213.76	<264.62	<241.80	73.66	76.29	86.76	79.15	74.44	111.17
RA-226	0.226	0.28	0.292	<19.09	21.75	<31.87	19.37	28.36	25.37	<5.69	<6.28	<5.83
RA-228	0.226	0.225	0.249	<48.10	<45.48	<61.55	20.28	19.95	18.45	<13.27	<11.21	<13.11
TH-230	<4.0	<3.9	<4.0	<1068.80	<1075.04	<1428.83	<227.33	<276.05	<251.79	<265.40	<287.00	<296.12
U-234	<13	<13	<13	<4046.18	<4630.94	<5715.30	<772.94	<727.78	<930.52	<1232.23	<1121.08	<1165.05
U-235	<.15	<.14	<.18	<41.23	<42.17	<52.76	8.43	<9.54	10.45	<11.37	<12.11	<11.65
U-238	.493	<.57	0.377	342.78	310.93	496.79	107.07	138.53	130.27	104.27	95.96	85.44

(a) Coal feed results are in pCi/g; all other results are in pCi/dscm, except as noted in header

TABLE III-31. RADIONUCLIDE RESULTS FOR SOLID AND GAS SAMPLES - CONT'D (pCi/dscm)

ANALYTE	ESP INLET LOCATION 10			ESP OUTLET LOCATION 12			BLANK REAGENT	BLANK LOCATION	BLANK LOCATION
	RUN 1	RUN 2	RUN 3	RUN 1	RUN 2	RUN 3	(pCi/sample)	(pCi/sample)	(pCi/sample)
PB-210	<278.29	<235.58	<204.79	43.58	62.08	72.03	71.81	45.82	<37.54
RA-226	<29.89	11.69	16.19	<4.39	3.89	<4.90	<6.17	<6.10	<4.10
RA-228	<58.75	<48.86	<56.56	<6.76	<8.72	<8.74	<11.89	<11.27	<9.90
TH-230	<1236.85	<1047.03	<1267.78	<209.46	<214.77	<202.80	<251.10	<295.77	<177.47
U-234	<5256.61	<4537.11	<4681.02	<844.59	<906.04	<874.13	<1101.32	<1173.71	<784.98
U-235	<49.47	<44.50	<54.61	<7.43	<8.39	<8.74	<10.57	<11.74	<7.51
U-238	421.56	453.71	473.95	72.30	81.21	75.52	90.75	91.08	81.23

- U^{218} is reported from the 63 keV energy line from the Th^{234} assuming that the U^{238} and Th^{234} are in secular equilibrium.

- Only a portion of the total particulate from Locations 2, 5, and 10 samples, which had considerable amount of loading, was prepared for analysis; results are corrected for the total sample. The entire filter and associated particulate from Locations 7 and 12 were digested for analysis.

- Results for the filter blank reagent and Location 7 and Location 12 Method 26A train blanks were calculated using the average gas sample volume from all locations.

- Results are not corrected for filter reagent blank or Method 26A train blanks.

For these analyses, Pb^{210} and U^{238} were detected in samples but were also detected at similar levels in the filter reagent blank and the Method 26A train blanks. Assuming a gas sample volume of 2 dscm, the train blank results for Pb^{210} and U^{238} will correspond to approximately 23 pCi/dscm for Pb^{210} and 42 pCi/dscm for U^{238}.

Flue gas results may be biased high. Based on the coal analyses of approximately 0.5 pCi of U^{238} and 12 percent ash, this would yield approximately 4.2 pCi/g of ash for U^{238}. The flue gas measurements for U^{238} at the ESP outlet are an average of 76 pCi/dscm or 34 pCi/dscm after blank subtraction, which is about 653 pCi/g of ash or about 2 orders of magnitude higher than would be expected.

IV. MATERIAL BALANCES

Material balances were performed on the boiler, the ESP, the combined boiler and ESP, and the SNRB™ system. The calculations are provided in Appendix D, with a summary of results presented in Appendix E. Separate material balances were calculated for each test run and for the average of the three runs. Material balances are reported for ash and thirteen metals.

Figures IV-1a and IV-1b show the control volumes for the material balance calculations for the boiler, the ESP, the SNRB™ process, and the combined boiler and ESP. These figures also show the flow paths into and out of each process. The ammonia flow into the SNRB™ process is not shown on these figures as it is believed to contain no ash or metals and, therefore, would not influence the material balances.

Assumptions

In performing the ash material balance calculations, a number of assumptions were made. The following paragraphs discuss these assumptions.

Boiler Ash Balance:

- Data on daily coal feed rates were not available. Therefore, the coal feed rate for each test day was assumed to be equal to the average coal feed rate for the entire test period. As the boiler operated at a nearly constant load during the entire test period, this is a reasonable assumption.

- The rate of pyrite rejects was measured during two periods during the tests. The average flow rate of pyrite rejects for each test was taken to be the average pyrite reject rate for the two periods during which pyrite reject rates were measured.

- The plant has no provisions for measuring the flow rates of the bottom ash stream or the economizer ash stream. However, knowing that the ash must achieve a material balance for the boiler, the total flow of bottom ash plus economizer hopper ash streams was taken to be equal to the difference between the ash entering the boiler with the coal and the fly ash exiting the boiler with the flue gas. Based on "Steam, Its

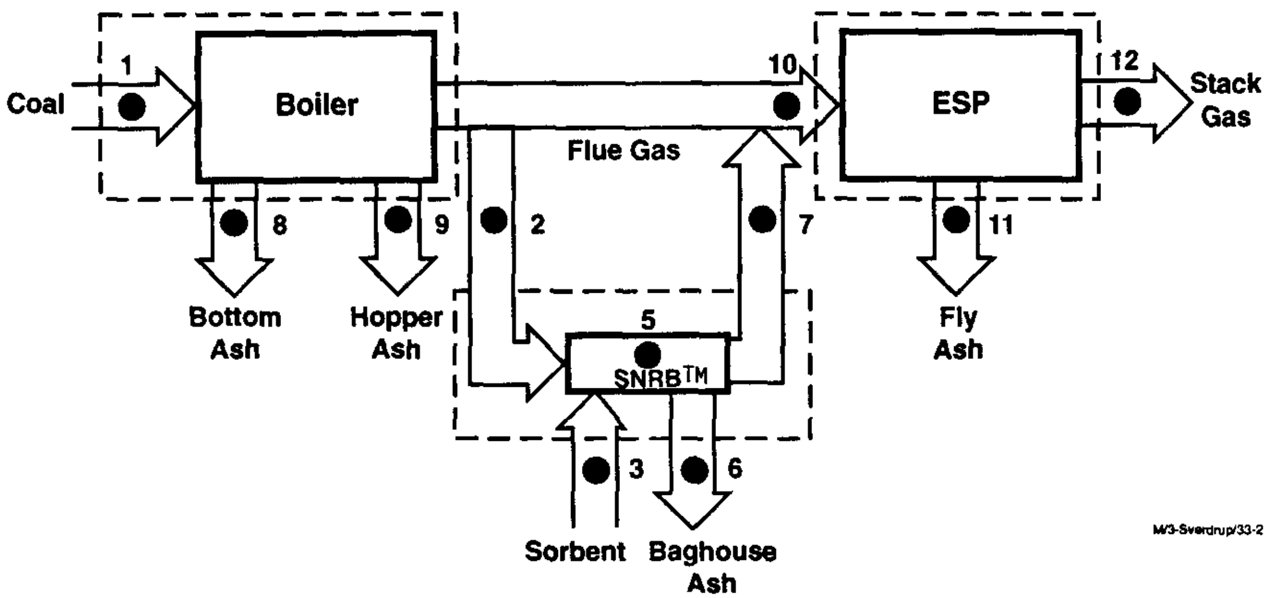


Figure IV-1a. Material Balance Boundaries for the Boiler, the ESP, and the SNRB™ Process

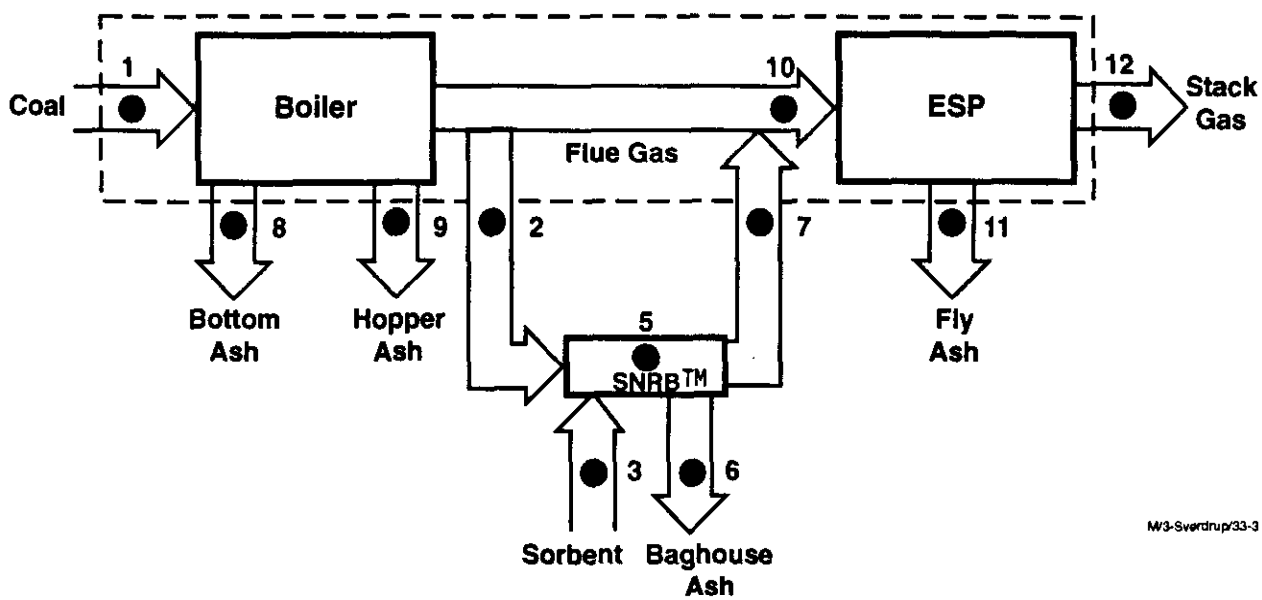


Figure IV-1b. Material Balance Boundaries for the Combined Boiler and ESP

Generation and Use", B&W, 1992, it was estimated that the bottom ash flow accounted for 75 percent of the ash that was not emitted as fly ash and the economizer ash flow accounted for 25 percent of the ash that was not emitted as fly ash. (For most metals the concentrations in the bottom ash and economizer ash were similar so that the assumed split between bottom ash and economizer ash had minimum impact on results.)

- The unburned carbon content of the particulate exiting the furnace was not determined. Lacking any specific data, the unburned carbon content for the particulate exiting the boiler was taken to be equal to the unburned carbon content of the collected ESP ash.

- Gas flow out of the boiler was equal to the gas flow at Location 10 minus the gas flow at Location 7 plus the gas flow at Location 2. That is

$$Q_{boiler\ exit} = Q_{10} - Q_7 + Q_2.$$

ESP Ash Balance:

- The plant has no provisions for measuring the flow rate of the ESP catch. However, knowing that the particulate must achieve a material balance for the ESP, the magnitude of the ESP catch was taken to be equal to the difference between the particulate entering the ESP and the particulate exiting the ESP.

- The unburned carbon content of the particulate exiting the ESP was not determined. Lacking any specific data, the unburned carbon content for the particulate exiting the ESP was taken to be equal to the unburned carbon content of the collected ESP ash.

SNRB™ System Ash Balance:

- Data on the baghouse solids generation rate were only available for 2 days. For material balance calculations, the baghouse solids generation rate was taken to be equal to the average flow rate for the 2 days for which data were available.

- The unburned carbon content of the particulate entering the SNRB™ system was not determined. Therefore, the unburned carbon content of the particulate entering the SNRB™ system was estimated from the carbon content of the baghouse catch and the ratio of particulate and hydrated lime entering the SNRB™ system.

- The unburned carbon content of the particulate exiting the SNRB™ system was not determined. Therefore, the unburned carbon content of the particulate exiting the SNRB™ system was the same as that for the material collected at the baghouse.

The calculated fraction of ash exiting the furnace as fly ash averaged approximately 68 and 73 percent of the ash input to the furnace using Location 2 and 10 data, respectively. These values are below the expected value of 80-85 percent for a pulverized coal-fired furnace. No explanation of this result is available.

Metals Material Balance:

In performing the metals material balances, the same assumptions reported for the ash material balances were made. However, some additional assumptions were required, including:

- Particulate loadings were only measured for "organic" test runs while metals analyses were only conducted on samples collected during "metals" test runs. Flue gas particulate loadings for the metals runs at the ESP inlet, the ESP outlet, the SNRB™ inlet, and the SNRB™ outlet were taken to be equal to the average of the respective particulate loadings as calculated for the three runs for which particulate emissions data were available, i.e., the organic runs.

- The SNRB™ system has no provisions for measuring the flow rate of the baghouse catch. However, knowing that the particulate must achieve a material balance for the baghouse, the magnitude of the baghouse catch was taken to be equal to the difference between the particulate entering the baghouse and the particulate exiting the baghouse for the three runs for which particulate emissions data were available (the organic runs). The baghouse catch rate for the metals runs was taken to be equal to the average of the baghouse catch rates calculated for the three organic runs.

- When "less than" values were reported for metals analyses, a value of zero was used in the metals material balance calculations.

- The metals emission rates for the boiler outlet and ESP inlet were based upon the metals concentrations measured at the SNRB™ inlet (Location 2), as sampling problems were experienced at the ESP inlet (Location 10) and the data from that location are questionable.

- Raw metals data were corrected for field blanks by subtracting the average of the two field blank values for each metal.

- When subtraction of field blank values from raw data produced negative values, a value of zero was used.

- Gas flow out of the boiler was equal to the gas flow at Location 10 minus the gas flow at Location 7 plus the gas flow at Location 2. That is

$$Q_{boiler\ exit} = Q_{10} - Q_7 + Q_2 .$$

- The mass flow rate of each metal exiting the boiler was equal to the mass flow rate at Location 10 minus that at Location 7, plus that at Location 2.

For the metals material balances, the assumptions regarding bottom ash, economizer ash, and ESP ash were necessary for two reasons. First, values for these flows were calculated from particulate loadings. Second, particulate emissions data were only available for the organic runs and the metals data were available for only the metals runs.

Ash: Material Balance Results

Results for material balances for ash were calculated as the quantity of material leaving the system divided by the quantity of material entering the system under consideration. The nature of the assumptions that were made in performing the ash balance calculations essentially forced the ash balances to show near perfect closure (i.e., within ±0.1 percent). These assumptions were necessary because it was not possible to measure all mass flow rates, and some of the mass flow rates were calculated by differences between the mass flow rates that were measured. Thus, the near perfect closure for the ash material balances does not reflect on the quality of the emissions test results.

Metals: Material Balance Results

Tables IV-1 through IV-13 show the results of the material balance calculations for the 13 metals of interest. Separate material balance calculations are shown for the boiler, the ESP, the combined boiler and ESP, and the SNRB™ system. Percent closure, as reported in these tables, is defined as 100 times the ratio of the material exiting the device to the material entering the device. A value of 100 indicates that the material

TABLE IV-1. MATERIAL BALANCE CLOSURES FOR MERCURY (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	48	62	110	73	32
ESP	199	177	120	165	41
Boiler and ESP	94	109	130	111	18
SNRB™ system	224	176	134	178	45

TABLE IV-2. MATERIAL BALANCE CLOSURES FOR CHROMIUM (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	78	44	131	84	44
ESP	165	421	79	222	178
Boiler and ESP	111	99	112	107	7
SNRB™ system	133	326	69	176	134

TABLE IV-3. MATERIAL BALANCE CLOSURES FOR CADMIUM (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	--[(a)]	--	--	NC[(b)]	NC
ESP	159	919	57	378	471
Boiler and ESP	--[(a)]	--	--	NC	NC
SNRB™ system	5.6	94	1.8	34	52

(a) Indicates material balance closure not calculated because the metal was not measured above the detection limit in the input stream.

(b) NC indicates not calculated.

TABLE IV-4. MATERIAL BALANCE CLOSURES FOR NICKEL (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	68	47	106	73	30
ESP	153	354	80	196	142
Boiler and ESP	93	90	91	91	1
SNRB™ system	117	439	50	202	208

TABLE IV-5. MATERIAL BALANCE CLOSURES FOR BARIUM (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	36	30	77	48	26
ESP	228	296	76	200	113
Boiler and ESP	63	60	63	62	2
SNRB™ system	21	28	7	19	11

TABLE IV-6. MATERIAL BALANCE CLOSURES FOR COBALT (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	81	45	181	102	70
ESP	138	309	62	170	127
Boiler and ESP	106	77	126	103	24
SNRB™ system	81	178	60	106	63

TABLE IV-7. MATERIAL BALANCE CLOSURES FOR MANGANESE (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	63	40	109	71	35
ESP	176	472	70	239	208
Boiler and ESP	90	88	87	88	1
SNRB™ system	144	339	64	183	141

TABLE IV-8. MATERIAL BALANCE CLOSURES FOR VANADIUM (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	70	48	117	78	35
ESP	156	281	97	178	94
Boiler and ESP	97	90	116	101	13
SNRB™ system	163	327	79	190	126

TABLE IV-9. MATERIAL BALANCE CLOSURES FOR BERYLLIUM (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	79	78	125	94	27
ESP	150	343	76	190	138
Boiler and ESP	107	165	104	125	35
SNRB™ system	0	180	38	73	95

TABLE IV-10. MATERIAL BALANCE CLOSURES FOR ARSENIC (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	161	56	127	115	53
ESP	286	608	346	413	171
Boiler and ESP	ND[a]	317	415	366	NC[b]
SNRB™ system	ND	716	396	556	NC

(a) ND = Not determined because sample from Location 7 (SNRB™ outlet) was lost during preparation.

(b) NC = Not calculated.

TABLE IV-11. MATERIAL BALANCE CLOSURES FOR LEAD (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	48	29	41	39	10
ESP	133	249	140	174	65
Boiler and ESP	ND[(a)]	65	56	61	NC[(b)]
SNRB™ system	ND	104	50	77	NC

(a) ND = Not determined because sample from Location 7 (SNRB™ outlet) was lost during preparation.
(b) NC = Not calculated.

TABLE IV-12. MATERIAL BALANCE CLOSURES FOR ANTIMONY (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	--[(a)]	--	--	NC[(b)]	NC
ESP	153	143	163	153	10
Boiler and ESP	--[(a)]	--	--	NC	NC
SNRB™ system	ND[(c)]	76	56	66	NC

(a) Indicates material balance closure not calculated because the metal was not measured above the detection limit in the input stream.
(b) NC = Not calculated.
(c) ND = Not determined because sample from Location 7 (SNRB™ outlet) was lost during preparation.

TABLE IV-13. MATERIAL BALANCE CLOSURES FOR SELENIUM (Percent)

System	4/27/93	4/29/93	4/30/93	Average	Standard Deviation
Boiler	50	30	102	61	37
ESP	120	113	62	98	32
Boiler and ESP	ND[(a)]	35	65	50	NC[(b)]
SNRB™ system	ND	187	90	138	NC

(a) ND = Not determined because sample from Location 7 (SNRB™ outlet) was lost during preparation.
(b) NC = Not calculated.

exiting the device was equal to the material entering the device, e.g., a perfect material balance. The following paragraphs summarize the results for each metal.

Mercury

The mercury content of coal feed and flue gas streams dominated the material balance calculations. Only for the ESP did the mercury mass flow rate from a solid stream (in the case of ESP hopper ash) make up as much as three percent of the mercury in one of the system's flue gas streams.

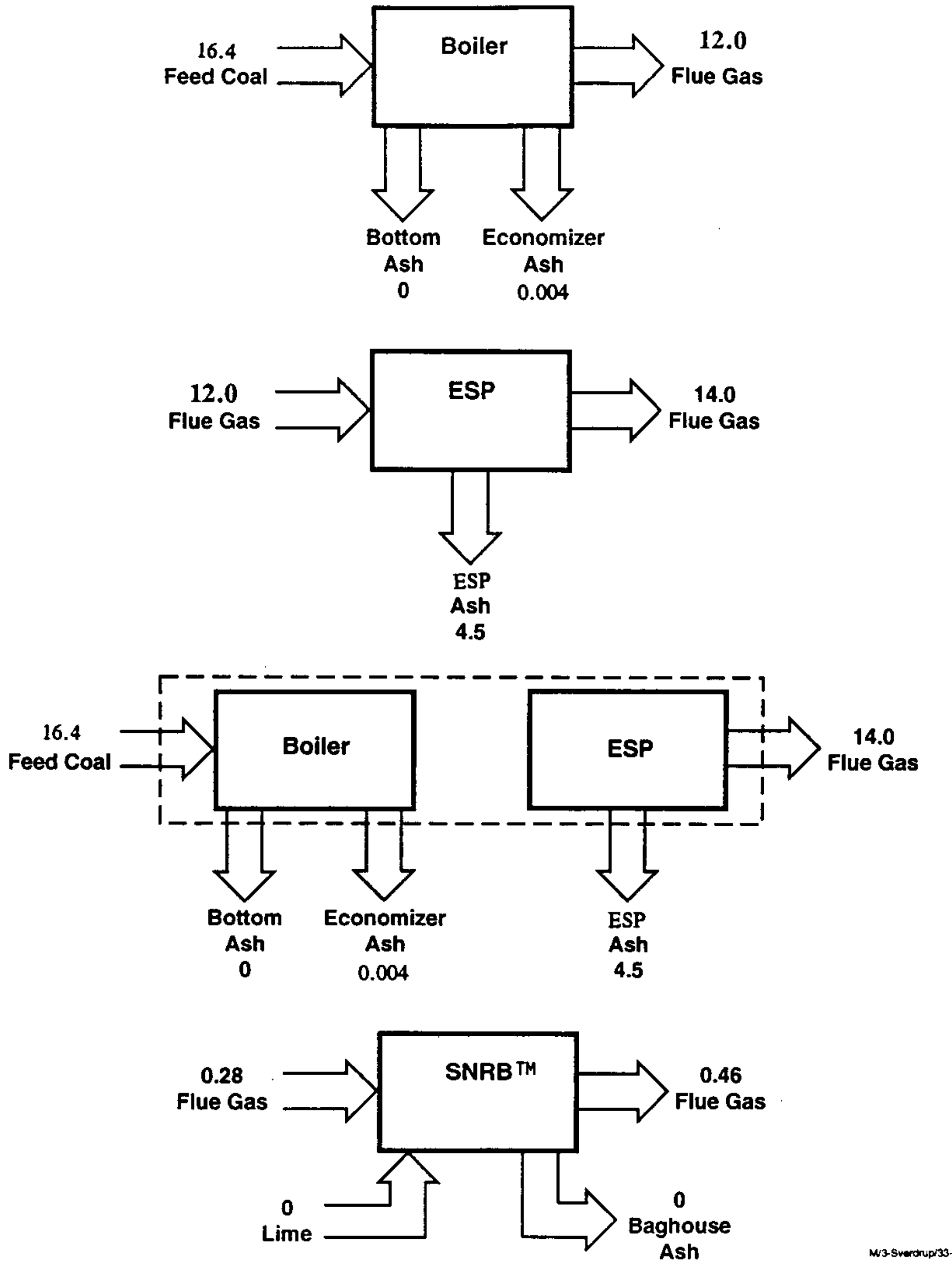
Table IV-1 shows that the combined mercury content of the three streams exiting the boiler equaled 48 to 110 percent (average 73 percent) of the measured mercury content of the feed coal.

The mercury content of the two streams exiting the ESP equaled 120 to 199 percent (average 165 percent) of the measured mercury content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, the mercury content of the four streams exiting these devices equaled 94 to 130 percent (average 111 percent) of the measured mercury content of the feed coal.

The mercury content of the two streams exiting the SNRB™ equaled 134 to 224 percent (average 178 percent) of the measured mercury content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process.

The results of the material balance calculation for the average of the three runs are shown in Figure IV-2. Mass flow rates of mercury are shown in lb/hr x 10^{-3}. The values for the boiler can be found in the fourth column (labelled average) in Rows 28, 29, 32, and 35 on the spreadsheet for mercury in Appendix E. The values shown for the ESP can be found in Rows 39, 40, and 43. The values for the boiler and ESP together can be found in Rows 32, 35, 40, 43, and 47. The values for the SNRB™ system can be found in Rows 51, 54, 57, and 58. These values are also summarized for all elements in Tables IV-16, IV-17, and IV-18 presented at the end of this section.



(Mass flow rates of
mercury in lb/hr x 10^3)

Figure IV-2. Schematic of Material Balance Results for Mercury

Chromium

Table IV-2 shows that the chromium content of the three streams exiting the boiler equaled 44 to 131 percent (average 84 percent) of the measured chromium content of the feed coal.

The chromium content of the two streams exiting the ESP equaled 79 to 421 percent (average 222 percent) of the measured chromium content of the flue gas exiting the boiler and entering the ESP. These results reflect a consistent mass flow of chromium out of the ESP in collected ash (1.430 ± 0.013 lb/hr) and measured incoming chromium in flue gas of 0.869, 0.342, and 1.782 lb/hr for Runs 1, 2, and 3, respectively. The relatively low value of 0.342 lb/hr for Run 2 resulted in the high value of 421 percent for the material balance closure.

Considering the boiler and ESP together, the chromium content of the four streams exiting these devices equaled 99 to 112 percent (average 107 percent) of the measured chromium content of the feed coal.

The chromium content of the two streams exiting the SNRB™ equaled 69 to 326 percent (average 176 percent) of the measured chromium content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process.

Cadmium

Because no cadmium was found in the pulverized coal being fired, no ratio could be determined to express the relationship between the cadmium content of the three streams exiting the boiler and the cadmium content of the feed coal.

Table IV-3 shows that the cadmium content of the two streams exiting the ESP equaled 57 to 919 percent (average 378 percent) of the measured cadmium content of the flue gas entering the ESP. The extremely high value for closure of the material balance for Run 2 is attributed to the low measured input rate of 1.9×10^{-3} lb/hr of cadmium compared to values of 9.4×10^{-3} and 16.3×10^{-3} for Runs 1 and 3. Cadmium in the output streams of the ESP system was all found in the ESP hopper ash at Location 11.

Considering the boiler and ESP together, because no cadmium was found in the pulverized coal being fired, no ratio could be determined to express the relationship between the cadmium content of the four streams exiting these devices and the cadmium content of the feed coal.

The cadmium content of the two streams exiting the SNRB™ equaled 2 to 94 percent (average 34 percent) of the measured cadmium content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process. The measured input rates in the flue gas were 0.21, 0.043, and 0.38 x 10^{-3} lb/hr for Runs 1, 2, and 3. The measured output rates in the flue gas were 0.012, 0.040, and 0.007 x 10^{-3} lb/hr. The value of 0.012 x 10^{-3} lb/hr for Run 1 does not include material from the front half of the sample train, which was lost during sample preparation.

Nickel

Table IV-4 shows that the nickel content of the three streams exiting the boiler equaled 47 to 106 percent (average 73 percent) of the measured nickel content of the feed coal. Process streams 1, 2, 8, and 9 provided significant nickel levels for the material balance calculations.

The nickel content of the two streams exiting the ESP equaled 80 to 354 percent (average 196 percent) of the measured nickel content of the flue gas entering the ESP. The incoming flue gas and outgoing ESP hopper ash contained essentially all the nickel in the material balance calculation. A relatively low value for incoming nickel for Run 2 (194 x 10^{-3} lb/hr compared to the average of 479 x 10^{-3} lb/hr) resulted in the high value of 354 percent for the material balance.

Considering the boiler and ESP together, the nickel content of the four streams exiting these devices equaled 90 to 93 percent (average 91 percent) of the measured nickel content of the feed coal.

The nickel content of the two streams exiting the SNRB™ equaled 51 to 439 percent (average 202 percent) of the measured nickel content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process. The high value of 439 percent for Run 2 resulted from relatively low measured input of nickel to the SNRB™ system combined with relatively high measured output (compared to the other two runs).

Barium

Table IV-5 shows that the barium content of the three streams exiting the boiler equaled 30 to 77 percent (average 48 percent) of the measured barium content of the feed coal. Process streams 1, 2, 8, and 9 played a major role in the material balance calculation. The barium concentration in process stream 2 averaged about 2.3 times that of process stream 10.

The barium content of the two streams exiting the ESP equaled 76 to 296 percent (average 200 percent) of the measured barium content of the flue gas exiting the furnace and entering the ESP. The material balance calculation for the ESP was driven by process streams 2 and 11.

Considering the boiler and ESP together, the barium content of the four streams exiting these devices equaled 60 to 63 percent (average 62 percent) of the measured barium content of the feed coal.

The barium content of the two streams exiting the SNRB™ equaled 7 to 28 percent (average 19 percent) of the measured barium content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process. The SNRB™ system had input flow of barium in the flue gas of 26.2, 21.8, and 89 x 10^{-3} lb/hr for Runs 1, 2, and 3, respectively. Input from the lime averaged 6.1 x 10^{-3} lb/hr, and output from the baghouse averaged 7.1 x 10^{-3} lb/hr.

Cobalt

Table IV-6 shows that the cobalt content of the three streams exiting the boiler equaled 45 to 181 percent (average 102 percent) of the measured cobalt content of the feed coal. As was the case for barium, process streams 1, 2, 8, and 9 played a major role in the material balance calculation for cobalt.

The cobalt content of the two streams exiting the ESP equaled 62 to 309 percent (average 170 percent) of the measured cobalt content of the flue gas entering the ESP. A low value for the input stream for Run 2 again caused the material balance closure to have a high value. The input mass flows of cobalt for Runs 1, 2, and 3 were 161, 57, and 385 x 10^{-3} lb/hr (based on Location 2 data).

Considering the boiler and ESP together, the cobalt content of the four streams exiting these devices equaled 77 to 126 percent (average 103 percent) of the measured cobalt content of the feed coal.

The cobalt content of the two streams exiting the SNRB™ equaled 60 to 178 percent (average 106 percent) of the measured cobalt content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process. Process streams 2, 3, and 6 predominated the material balance calculation. The average mass flow rates of cobalt in these three process streams was 4.7, 3.4, and 7.1 x 10^{-3} lb/hr.

Manganese

Table IV-7 shows that the manganese content of the three streams exiting the boiler equaled 40 to 109 percent (average 71 percent) of the measured manganese content of the feed coal. The lowest value of 44 percent for Run 2 is a consequence of a relatively low mass flow out in process stream 2.

The manganese content of the two streams exiting the ESP equaled 70 to 472 percent (average 239 percent) of the measured manganese content of the flue gas entering the ESP. The ESP calculations were again dominated by process streams 2 and 11. The input flow of manganese from Run 2 was relatively low yielding the high closure of 472 percent. The output in the flue gas (stream 12) was variable (0.77, 44, 3.8 x 10^{-3} lb/hr), but this stream had a negligible influence on the material balance for manganese.

Considering the boiler and ESP together, the manganese content of the four streams exiting these devices equaled 87 to 90 percent (average 88 percent) of the measured manganese content of the feed coal.

The manganese content of the two streams exiting the SNRB™ equaled 64 to 339 percent (average 183 percent) of the measured manganese content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process. The input mass flow of manganese in the flue gas was relatively low for Run 2 yielding the high closure of 339 percent. The average mass flow rates of manganese for process streams 2, 3, 6, and 7 were 23.1, 2.3, 30.3, and 0.02 x 10^{-3} lb/hr.

Vanadium

Table IV-8 shows that the vanadium content of the three streams exiting the boiler equaled 48 to 117 percent (average 78 percent) of the measured vanadium content of the feed coal.

The vanadium content of the two streams exiting the ESP equaled 97 to 281 percent (average 178 percent) of the measured vanadium content of the flue gas entering the ESP. The high closure of 281 percent for Run 2 resulted from a relatively low measured concentration of vanadium in the input stream to the ESP.

Considering the boiler and ESP together, the vanadium content of the four streams exiting these devices equaled 90 to 116 percent (average 101 percent) of the measured vanadium content of the feed coal.

The vanadium content of the two streams exiting the SNRB™ equaled 79 to 327 percent (average 190 percent) of the measured vanadium content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process. The relatively high closure value of 327 percent for Run 2 was the result of the combination of the lowest value of the three runs for the flue gas input and the highest value of the three runs for the SNRB™ solids outflow.

Beryllium

Table IV-9 shows that the beryllium content of the three streams exiting the boiler equaled 78 to 125 percent (average 94 percent) of the measured beryllium content of the feed coal.

The beryllium content of the two streams exiting the ESP equaled 76 to 343 percent (average 190 percent) of the measured beryllium content of the flue gas entering the ESP. The high value of 343 percent for closure on beryllium in Run 2 is a consequence of the relatively low input flow.

Considering the boiler and ESP together, the beryllium content of the four streams exiting these devices equaled 104 to 165 percent (average 125 percent) of the measured beryllium content of the feed coal.

The beryllium content of the two streams exiting the SNRB™ equaled 0 to 180 percent (average 73 percent) of the measured beryllium content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process. The spread in the closure for beryllium in the SNRB™ system is in part a consequence of the very low concentrations in the system. Process streams 2 and 6 had values ranging from 0 to 2.4×10^{-3} lb/hr. No beryllium was found in process streams 3 and 7.

Arsenic

Table IV-10 shows that the arsenic content of the three streams exiting the boiler equaled 56 to 161 percent (average 115 percent) of the measured arsenic content of the feed coal.

The arsenic content of the two streams exiting the ESP equaled 286 to 608 percent (average 413 percent) of the measured arsenic content of the flue gas entering the ESP. The closure on material balances for arsenic was high for all runs for the ESP, boiler and ESP, and SNRB™ system.

Considering the boiler and ESP together, the arsenic content of the four streams exiting these devices equaled 317 to 415 percent (average 366 percent) of the measured arsenic content of the feed coal.

The arsenic content of the two streams exiting the SNRB™ equaled 396 to 716 percent (average 556 percent) of the measured arsenic content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process.

Lead

Table IV-11 shows that the lead content of the three streams exiting the boiler equaled 29 to 48 percent (average 39 percent) of the measured lead content of the feed coal.

The lead content of the two streams exiting the ESP equaled 133 to 249 percent (average 174 percent) of the measured lead content of the flue gas entering the ESP.

Considering the boiler and ESP together, the lead content of the four streams exiting these devices equaled 56 to 65 percent (average 61 percent) of the measured lead content of the feed coal.

The lead content of the two streams exiting the SNRB™ equaled 50 to 104 percent (average 77 percent) of the measured lead content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process.

Antimony

Because no antimony was found in the pulverized coal being fired, no ratio could be determined to express the relationship between the antimony content of the three streams exiting the boiler and the antimony content of the feed coal.

Table IV-12 shows that the antimony content of the two streams exiting the ESP equaled 143 to 163 percent (average 153 percent) of the measured antimony content of the flue gas exiting the furnace and entering the ESP.

Considering the boiler and ESP together, because no antimony was found in the pulverized coal being fired, no ratio could be determined to express the relationship between the antimony content of the four streams exiting these devices and the antimony content of the feed coal.

The antimony content of the two streams exiting the SNRB™ equaled 56 to 76 percent (average 66 percent) of the measured antimony content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process. Flue gas into SNRB™ and baghouse collected ash out of SNRB™ accounted for essentially all of the measured antimony.

Selenium

Table IV-13 shows that the selenium content of the three streams exiting the boiler equaled 30 to 102 percent (average 61 percent) of the measured selenium content of the feed coal. The low closure values for Runs 1 and 2 result from a 50 percent higher input rate and output rates that were 73 and 45 percent of that for Run 3.

The selenium content of the two streams exiting the ESP equaled 62 to 120 percent (average 98 percent) of the measured selenium content of the flue gas exiting the furnace and entering the ESP. Selenium was a significant factor in all three process streams for the material balance. This reflects the partitioning between the vapor and solid phases that is characteristic of selenium at these temperatures.

Considering the boiler and ESP together, the selenium content of the four streams exiting these devices equaled 35 to 65 percent (average 50 percent) of the measured selenium content of the feed coal.

The selenium content of the two streams exiting the SNRB™ equaled 90 to 187 percent (average 138 percent) of the measured selenium content of the flue gas entering the SNRB™ and of the hydrated lime introduced into the SNRB™ process.

Metals: Discussion of Material Balance Results

Examination of the above results for material balances on the thirteen metals of interest shows that:

- The amount of metals accounted for in the three streams exiting the boiler (Locations 2, 8, and 9) was less than the metal found in the feed coal stream (Location 1) except for cobalt and arsenic.

- The amount of metals accounted for in the two streams exiting the ESP (Locations 11 and 12) was significantly greater than the metal found in the flue gas stream entering the ESP (both for Location 10 and based on Location 2 data) except for selenium.

- For most metals, there was reasonably close agreement between the amount of metals accounted for in the four streams exiting the boiler and ESP (Locations 8, 9, 11, and 12) and the metal found in the feed coal stream (Location 1).

- The relationship between the amount of metals accounted for in the streams entering and exiting the SNRB™ process was varied, but most often significantly more metal was found in the streams exiting the SNRB™ (Locations 6 and 7) than was found in the streams entering the SNRB™ (Locations 2 and 3).

These results are most easily explained by concluding that, for most metals, too little of the metal was measured in the flue gas stream exiting the boiler (both at Location 10 and at Location 2 from which data for material balances were used). The fact that the overall material balances for the boiler and ESP together were in reasonable balance suggests that the data for the metals contents of the feed coal and for the other streams exiting the boiler and the ESP must have been reasonably correct. Also, the reasonable balances achieved for the boiler and ESP together suggest that the assumptions made in performing the material balance calculations were reasonable, at least as concerns the boiler and the ESP.

If significantly more metal had been found in the flue gas stream exiting the boiler, the material balances for the boiler and for the ESP would have more nearly in agreement. That is, the material balance results for the boiler would be higher and those for the ESP would be lower. If significantly more metal had been found in the flue gas stream exiting the boiler, the material balance percentages for metals for the SNRB™ process would have been lower. This would more nearly balance metal entering and exiting for some metals and produced a greater imbalance for other metals.

The low amount of metal exiting the boiler may be the result of a low bias in the particulate phase trace metals concentrations. The fly ash entering the ESP (or exiting the boiler) -- Locations 10 and 2 -- would be expected to be similar in concentration with the ash collected by the ESP and the ash that drops out in the economizer. A comparison of metal concentrations at these locations is provided in Table IV-14. The metal concentrations in coal feed ash is also included for further comparison.

Note that the average particulate loadings used to calculate the data presented in Table IV-14 were derived from Method 26A samples, rather than the Method 29 samples analyzed for trace metals.

As Table IV-14 shows, the concentration of the fly ash collected at Location 2 (exiting the boiler and entering the SNRB™) more closely compares with the concentrations of the economizer ash and the ESP ash than does the fly ash collected at Location 10 (exiting the boiler and entering the ESP). This comparison strengthens the suggestion that sampling difficulties may have affected the validity of collected samples at Location 10 (see Section VII and Page III-32). The use of Location 2 data for material balances is supported by this

TABLE IV-14. COMPARISON OF METAL CONCENTRATIONS ($\mu g/g$)

	Coal Feed Ash[(a)] (Location 1)	Fly Ash Entering SNRB™ (Location 2)	Fly Ash Entering ESP (Location 10)	Economizer Ash (Location 9)	ESP Ash (Location 11)
Cr	125	92	42	120	124
Cd	ND[(b)]	0.85	0.3	8	1
Ni	67	44	19	53	52
Ba	394	182	19	190	233
Co	19	19	7	16	19
Mn	158	92	41	144	134
V	186	132	66	147	158
Be	5.8	5.3	2	6	6
As	42	54	34	67	194
Pb	44	22	14	5	14
Sb	ND	0.99	0.9	0.8	1.4

(a) Calculated using average coal ash value of 12 percent and metal concentration in coal ($\mu g/g$) from Table III-18 and III-20.

(b) ND = Not detected.

comparison. Use of Location 2 data provides improved material balances over use of Location 10 data. For example, the average material balance closure for nickel across the boiler and the ESP would be 47 and 390 percent using Location 10 data but is 73 and 196 percent using Location 2 data, as presented here. However, while use of Location 2 data improves material balances, the trend noted above still exists to some extent.

Material Balance Results When Data Outliers are Eliminated

To assess the influence of extreme values of trace metal concentrations on material balance calculations, the data were screened and new material balance calculations were made. To screen the data the average and standard deviations of trace metal mass flow rates in the process streams were calculated. If either of the low or high values for the three runs was outside one standard deviation, it was eliminated and a new average value was calculated for use in the material balance. For several sets of data, the three values were widely dispersed with no one value outside the range of ± one standard deviation. Then all three values were used in the average. For several process streams and some metals, the data at the ESP or SNRB™ outlet were widely scattered, but these streams did not significantly affect the material balance. Then, of course, this procedure of screening the data had no significant effect on the material balance. The results of this exercise are shown in Table IV-15. Compared to the average values shown in Tables IV-1 through IV-13, the material balance closures shown in Table IV-15 show marked improvement for the ESP. This improvement reflects the change in input mass flow rate to the calculation. Nevertheless, considering all four systems shown in Table IV-15, the closures are still greater than 200 percent or less than 50 percent for five metals. For the entire SNRB™ process, cadmium, barium, and arsenic have closures outside the range of 50 to 200 percent.

TABLE IV-15. RESULTS OF MATERIAL BALANCE CALCULATIONS USING AVERAGE DATA SCREENED FOR EXTREME VALUES ON INDIVIDUAL RUNS

	Material Balance Closure (percent)			
Element	Boiler	ESP	Boiler and ESP	SNRB™
Hg	73	165	111	155
Cr	84	122	107	101
Cd	NC[a]	108	NC	34
Ni	73	116	91	84
Ba	48	200	62	19
Co	102	100	103	106
Mn	71	123	88	104
V	78	126	101	121
Be	94	113	125	73
As	115	316	366	556
Pb	39	136	61	77
Sb	NC	153	NC	66
Se	61	98	50	138

(a) NC = not calculated.

TABLE IV-16. MATERIAL BALANCES FOR BOILER (lb/hr)

Metal	G50 Metal in Pulverized Coal	G56 Metal in Bottom Ash	G60 Metal in Economizer Ash	Metal in Flue Gas
Mercury	0.016	0	0.000004	0.012
Chromium	1.85	0.39	0.14	1.00
Cadmium	0	0.010	0.010	0.009
Nickel	1.01	0.19	0.06	0.48
Barium	5.98	0.64	0.22	1.97
Cobalt	0.29	0.058	0.019	0.20
Manganese	2.40	0.51	0.17	1.00
Vanadium	2.82	0.52	0.17	1.43
Beryllium	0.084	0.018	0.007	0.057
Arsenic	0.63	0.017	0.078	0.59
Lead	0.67	0.022	0.006	0.24
Antimony	0	0.0004	0.0003	0.011
Selenium	0.34	0	0	0.19

TABLE IV-17. MATERIAL BALANCES FOR ESP (lb/hr)

Metal	Metal in Incoming Flue Gas	Metal in ESP Catch	Metal in Exiting Flue Gas
Mercury	0.012	0.004	0.014
Chromium	1.00	1.43	0.0016
Cadmium	0.009	0.014	0
Nickel	0.48	0.66	0.0001
Barium	1.97	2.78	0.0016
Cobalt	0.20	0.21	0
Manganese	1.00	1.40	0.02
Vanadium	1.43	2.09	0.0015
Beryllium	0.057	0.075	0
Arsenic	0.59	2.23	0.005
Lead	0.24	0.38	0.00008
Antimony	0.011	0.016	0.00009
Selenium	0.19	0.12	0.05

TABLE IV-18. MATERIAL BALANCES FOR SNRB™ PROCESS (lb/hr)

Metal	Metal in Incoming Flue Gas	Metal in Sorbent	Metal in Baghouse Catch	Metal in Exiting Flue Gas
Mercury	0.00028	0	0	0.00046
Chromium	0.023	0.0006	0.028	0.0001
Cadmium	0.0002	0	0	0.00002
Nickel	0.011	0	0.012	0.001
Barium	0.046	0.006	0.007	0.000004
Cobalt	0.0047	0.0034	0.0071	0.00003
Manganese	0.023	0.002	0.030	0.00002
Vanadium	0.033	0.002	0.051	0
Beryllium	0.0013	0	0.0006	0
Arsenic	0.013	0.0007	0.063	0.00004
Lead	0.0054	0	0.0033	0.000017
Antimony	0.0002	0.0006	0.0005	0.00003
Selenium	0.0043	0	0.0049	0

V. EMISSION FACTORS

Emission factors for ash matter and trace substances were calculated for flue gas streams leaving the boiler (Location 10), the ESP (Location 12), and the SNRB™ process (Location 7). Sample calculations are shown in Appendix D. Average values from field train blanks were subtracted from values measured in flue gas samples to calculate levels of substances. Where indicated by the ND flag, the substance was not detected or was detected at a level below the level in the train blank. In this case, the emission factor presented is calculated from half of the detection limit. Results are shown in Tables V-1 through V-10. Emission factors are shown for each sampling day and for the average value. The standard deviation and the 95 percent confidence interval are also shown. Standard deviations were calculated using the following:

$$SD = \sqrt{\frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)}{n-1}}$$

Where less than three data were available, standard deviations were considered meaningless and were not calculated.

Ninety-five percent confidence intervals were calculated by multiplying the standard deviation by a value extracted from t-test tables for the 0.975 interval and three data points (4.303) and dividing by the square root of the number of data points (3).

TABLE V-1. EMISSION FACTORS FOR ASH EXITING THE BOILER, ESP, AND SNRB™[a]

System	4/26/93	5/1/93	5/2/93	Average	Standard Deviation	95% Confidence Interval (±)
Boiler	5.78	6.02	8.69	6.83	1.62	4.0
ESP	0.047	0.055	0.033	0.045	0.011	0.03
SNRB™	0.037	0.027	0.018	0.027	0.009	0.02

(a) Values in lb/10E06 BTU.

TABLE V-2. EMISSION FACTORS FOR METALS EXITING THE ESP

Metal	Emission Factor (lb/10E12 BTU)									
		4/27/93		4/29/9		4/30/93	Average(a)		Standard Deviation	95% Confidence Interval (+/-)
Chromium		0.07		1.78		0.87	0.91		0.85	2.12
Cadmium	ND<	6.60	ND<	6.59	ND<	6.62	6.60	#	0.01	0.03
Nickel	ND<	7.92	ND<	7.91	ND<	7.94	7.92	#	0.02	0.04
Barium	*ND<	6.60		3.00	*ND<	6.62	5.41	#	2.09	5.18
Cobalt	ND<	7.92	ND<	7.91	ND<	7.94	7.92	#	0.02	0.04
Manganese		0.49		27.86		2.41	10.25		15.28	37.95
Vanadium	ND<	7.04		2.71		0.46	3.40	#	3.35	8.31
Beryllium	ND<	6.60	ND<	6.59	ND<	6.62	6.60	#	0.01	0.03
Arsenic		1.57		5.61		1.63	2.93		2.31	5.75
Lead	*ND<	0.11		0.05	ND<	0.11	0.09	#	0.04	0.09
Antimony		0.11		0.09		0.04	0.08		0.04	0.09
Selenium		74.46		5.52		9.95	29.98		38.59	95.86
Mercury		7.92		8.51		9.89	8.77		1.01	2.51

(a)# indicates average emission factor calculated from one or more non-detect values.

TABLE V-3. EMISSION FACTORS FOR METALS EXITING SNRB™

Metal	Emission Factor (lb/10E12 BTU)					
	4/27/93	4/29/93	4/30/93	Average(c)	Standard Deviation	95% Confidence Interval (+/-)
Chromium	ND< 6.29	10.40	*ND< 6.27	7.65 #	2.38	5.91
Cadmium	0.33	1.11	ND< 7.53	2.99 #	3.95	9.81
Nickel	2.50	89.82	ND< 9.03	33.78 #	48.64	120.84
Barium	ND< 7.54	0.30	*ND< 7.52	5.12 #	4.17	10.36
Cobalt	ND< 9.05	2.73	ND< 9.03	6.94 #	3.65	9.06
Manganese	*ND< 7.54	1.28	0.24	3.02 #	3.95	9.81
Vanadium	ND< 8.17	ND< 8.09	ND< 8.03	8.10 #	0.07	0.18
Beryllium	ND< 7.54	ND< 7.59	ND< 7.53	7.55 #	0.03	0.08
Arsenic	NS(a)	2.18	0.27	1.22	NC(b)	NC
Lead	NS	0.81	ND< 0.20	0.51 #	NC	NC
Antimony	NS	1.51	ND< 0.05	0.78 #	NC	NC
Selenium	NS	*ND< 0.10	ND< 0.09	0.10 #	NC	NC
Mercury	11.05	11.27	15.11	12.48	2.28	5.67

(a) NS indicates no sample data.
(b) NC indicates not calculated because too few data.
(c)# indicates average emission factor calculated from one or more non-detect values.

TABLE V-4. EMISSION FACTORS FOR CHLORIDE/FLUORIDE EXITING ESP AND SNRB™

Substance	System	4/26/93	5/1/93	5/2/93	Average	Standard Deviation	95% Confidence Interval (±)
Fluoride	ESP	4,232	5,883	6,349	5,488	1,112	2,764
Fluoride	SNRB™	72	ND < 1	39	37#	35	87
Chloride	ESP	31,200	34,300	31,480	32,334	1,742	4,328
Chloride	SNRB™	601	807	2	470	418	1,038

# Indicates average calculated from one or more nondetect values.

TABLE V-5. EMISSION FACTORS FOR VOC EXITING THE ESP (lb/10E12 BTU) (a)

Analyte	4/30/93	
trichlorofluoromethane (Freon-11)	ND<	1.24
1,1-dichloroethene	ND<	0.88
dichloromethane	##ND<	0.77
3-chloropropene		9.54
1,1,2-trichloro-1,2,2-trifluoroethane	ND<	1.69
1,1-dichloroethane		9.93
cis-1,2-dichloroethene	ND<	0.88
trichloromethane		5.56
1,2-dichloroethane	ND<	0.89
1,1,1-trichloroethane		3.33
benzene		25.44
carbon tetrachloride	ND<	1.39
1,2-dichloropropane	ND<	1.02
trichloroethene	ND<	1.18
cis-1,3-dichloropropene		6.61
trans-1,3-dichloropropene	ND<	1.00
1,1,2-trichloroethane	ND<	1.20
toluene (b)	##ND<	0.83
1,2-dibromoethane		4.31
tetrachloroethene	ND<	1.50
chlorobenzene	ND<	1.02
m+p-xylene		4.32
4-ethyl toluene		3.77
1,3,5-trimethylbenzene		3.92
1,2,4-trimethylbenzene	##ND<	1.08
p-dichlorobenzene		358.15

(a) Emission factors were calculated for all VOC for which recovery of the spiked material exceeded 80 percent. Emission factors were not calculated for the remaining VOC analyzed.
(b) Spike recovery less than 80 percent.
##Indicates subtraction of train blank reduced concentration to 0.

TABLE V-6. EMISSION FACTORS FOR VOC EXITING THE SNRB™(a)

Analyte	Emission Factor (lb/10E12 BTU)#								
	4/30/93		4/30/93		5/01/93		Average	Standard Deviation	95% Confidence Interval (+/-)
trichlorofluoromethane (Freon-11)	ND<	1.4	ND<	1.4	ND<	1.5	1.45 **	0.08	0.20
1,1-dichloroethene	ND<	1.0	ND<	1.0	ND<	1.1	1.03 **	0.06	0.14
dichloromethane	##ND<	0.9	##ND<	0.9		1330.9	444.22 **	767.90	1907.72
3-chloropropene		2.9	##ND<	0.8		22.9	8.87 **	12.20	30.30
1,1,2-trichloro-1,2,2-trifluoroethane	ND<	1.9	ND<	1.9	ND<	2.1	1.98 **	0.11	0.28
1,1-dichloroethane		0.8		1.6	ND<	1.1	1.16 **	0.42	1.03
cis-1,2-dichloroethene	ND<	1.0	ND<	1.0	ND<	1.1	1.03 **	0.06	0.14
trichloromethane	ND<	1.2	ND<	1.2	ND<	1.3	1.26 **	0.07	0.18
1,2-dichloroethane	ND<	1.0	ND<	1.0	ND<	1.1	1.05 **	0.06	0.15
1,1,1-trichloroethane	ND<	1.4	ND<	1.4		4.9	2.54 **	2.04	5.06
benzene		10.4		4.7		6.5	7.19	2.88	7.15
carbon tetrachloride	ND<	1.6	ND<	1.6	ND<	1.7	1.63 **	0.09	0.23
1,2-dichloropropane	ND<	1.2	ND<	1.2	ND<	1.3	1.20 **	0.07	0.17
trichloroethene	ND<	1.3	ND<	1.3	ND<	1.5	1.39 **	0.08	0.19
cis-1,3-dichloropropene	##ND<	1.1	##ND<	1.1		3.7	1.99 **	1.48	3.68
trans-1,3-dichloropropene		1.3	ND<	1.1	ND<	1.3	1.22 **	0.07	0.18
1,1,2-trichloroethane	ND<	1.4	ND<	1.4	ND<	1.5	1.41 **	0.08	0.20
toluene*	##ND<	0.9	##ND<	0.9		0.2	0.71 **	0.40	1.00
1,2-dibromoethane		1.6	ND<	1.9	ND<	2.1	1.87 **	0.28	0.70
tetrachloroethene	ND<	1.7	ND<	1.7	ND<	1.9	1.76 **	0.10	0.25
chlorobenzene	ND<	1.2	ND<	1.2	ND<	1.3	1.20 **	0.07	0.17
m+p-xylene		22.5	##ND<	1.1	##ND<	1.2	8.25 **	12.31	30.59
4-ethyl toluene	ND<	1.2	ND<	1.2	ND<	1.4	1.27 **	0.07	0.18
1,3,5-trimethylbenzene	ND<	1.2	ND<	1.2	ND<	1.4	1.27 **	0.07	0.18
1,2,4-trimethylbenzene	##ND<	1.2	##ND<	1.2	ND<	1.4	1.27 **	0.07	0.18
p-dichlorobenzene		76.8	ND<	1.5	ND<	1.7	26.66 **	43.44	107.91

(a) Emission factors were calculated for all VOC for which spike recovery exceeded 80 percent.
*Recoveries for analyte in field spike are less than 80 percent.
**Indicates average emission factor calculated from one or more non-detect values.
#Sample results are corrected for trip blank.
##Indicates subtraction of train blank reduced concentration to 0.

TABLE V-7. EMISSION FACTORS FOR PAH EXITING ESP (lb/10E12 BTU)

Compound	R1-L12	R2-L12	R3-L12	Average	Standard Deviation	95% Confidence Interval (+/-)
	Location 12 - ESP Outlet					
Naphthalene	*ND<0.0000012	*ND<0.0000012	*ND<0.0000012	*ND<0.0000012 #	0.0000	0.0000
2-Methylnaphthalene	0.00047	*ND<0.0000012	*ND<0.0000012	0.0002 #	0.0003	0.0007
1-Methylnaphthalene	0.00083	*ND<0.0000012	*ND<0.0000012	0.0003 #	0.0005	0.0012
Biphenyl	0.00134	0.00074	0.00027	0.0008	0.0005	0.0013
Acenaphthylene	0.00165	0.00191	0.00612	0.0032	0.0025	0.0062
Acenaphthene	*ND<0.0000012	0.01074	0.00183	0.0042 #	0.0057	0.0143
Fluorene	0.01617	0.01022	0.01023	0.0122	0.0034	0.0085
Phenanthrene	0.04767	0.04505	0.16875	0.0872	0.0707	0.1756
Anthracene	0.00603	0.00405	0.00804	0.0060	0.0020	0.0049
Fluoranthene	0.06208	0.03354	0.08293	0.0595	0.0248	0.0616
Pyrene	0.02646	0.01577	0.03562	0.0260	0.0099	0.0247
Benzo[a]anthracene	*ND<0.0000024	0.01275	0.01692	0.0099 #	0.0088	0.0219
Chrysene	0.00185	0.01768	0.09926	0.0396	0.0523	0.1299
Benzofluoranthenes	0.00351	0.02478	0.01471	0.0143	0.0106	0.0264
Benzo[e]pyrene	0.00489	0.00867	0.00466	0.0061	0.0022	0.0056
Benzo[a]pyrene	0.03372	0.01232	0.00313	0.0164	0.0157	0.0390
Indeno[1,2,3-c,d]pyrene	0.00402	0.01355	0.00379	0.0071	0.0056	0.0138
Dibenzo[a,h]anthracene	0.00114	0.00494	0.00340	0.0032	0.0019	0.0047
Benzo[g,h,i]perylene	0.00434	0.01086	0.00689	0.0074	0.0033	0.0082

*Indicates train blank correction reduced concentration to less than 0.
#Indicates average emission factor calculated from one or more non-detect values.

TABLE V-8. EMISSION FACTORS FOR PAH EXITING SNRB™ (lb/10E12 BTU)

Compound	Location 7 - SNRB Outlet R1-L7	R2-L7	R3-L7	Average	Standard Deviation	95% Confidence Interval (+/-)
Naphthalene	*ND<0.0000012	0.2735	0.3314	0.2016 #	0.1770	0.4397
2-Methylnaphthalene	*ND<0.0000012	0.0339	0.0103	0.0147 #	0.0174	0.0432
1-Methylnaphthalene	0.0004	0.0189	0.0047	0.0080	0.0097	0.0240
Biphenyl	0.0048	0.0158	0.0106	0.0104	0.0055	0.0137
Acenaphthylene	0.0013	0.0029	0.0030	0.0024	0.0010	0.0024
Acenaphthene	*ND<0.0000012	0.0231	0.0013	0.0081 #	0.0130	0.0323
Fluorene	0.0287	0.0432	0.1067	0.0595	0.0415	0.1030
Phenanthrene	0.0160	0.2697	0.0657	0.1171	0.1344	0.3340
Anthracene	0.0073	0.0127	0.0035	0.0078	0.0047	0.0116
Fluoranthene	0.0070	0.1386	0.0322	0.0593	0.0699	0.1735
Pyrene	0.0026	0.0555	0.0079	0.0220	0.0292	0.0724
Benzo[a]anthracene	0.0071	0.0053	0.0016	0.0047	0.0028	0.0069
Chrysene	0.0133	0.0097	0.0128	0.0119	0.0019	0.0048
Benzofluoranthenes	0.0185	0.0207	0.0096	0.0163	0.0059	0.0146
Benzo[e]pyrene	0.0088	0.0100	0.0013	0.0067	0.0047	0.0117
Benzo[a]pyrene	0.0118	0.0057	0.0066	0.0080	0.0033	0.0083
Indeno[1,2,3-c,d]pyrene	0.0139	0.0087	0.0035	0.0087	0.0052	0.0129
Dibenzo[a,h]anthracene	0.0168	0.0024	0.0005	0.0065	0.0089	0.0222
Benzo[g,h,i]perylene	0.0168	0.0100	0.0036	0.0101	0.0066	0.0164

*Indicates train blank correction reduced concentration to less than 0.
#Indicates average emission factor calculated from one or more non-detect values.

TABLE V-9. EMISSION FACTORS FOR DIOXINS/FURANS EXITING ESP (lb/10E12 BTU)

ANALYTE	Location 12 - ESP Outlet R1-L12	R2-L12	R3-L12	Average	Standard Deviation	95% Confidence Interval (+/-)
2378-TCDD	ND< 0.000000758	0.000008882	ND< 0.000000929	0.000003523 #	0.000004642	0.000011532
12378-PeCDD	ND< 0.000000669	ND< 0.000000359	ND< 0.000001681	0.000000903 #	0.000000691	0.000001717
123478-HxCDD	ND< 0.000001873	ND< 0.000001167	ND< 0.000001062	0.000001367 #	0.000000441	0.000001096
123678-HxCDD	ND< 0.000001516	ND< 0.000000988	ND< 0.000000929	0.000001144 #	0.000000323	0.000000804
123789-HxCDD	0.000002950	ND< 0.000002290	ND< 0.000001504	0.000002248 #	0.000000724	0.000001799
1234678-HpCDD	0.000009576	0.000010471	0.000008383	0.000009477	0.000001048	0.000002603
OCDD	0.000007404	0.000027815	0.000012364	0.000015861	0.000010645	0.000026447
2378-TCDF	0.000001798	0.000001415	ND< 0.000001062	0.000001425 #	0.000000368	0.000000915
12378-PeCDF	ND< 0.000001695	ND< 0.000001033	ND< 0.000000663	0.000001130 #	0.000000522	0.000001298
23478-PeCDF	ND< 0.000002319	ND< 0.000001257	ND< 0.000000840	0.000001472 #	0.000000762	0.000001894
123478-HxCDF	0.000015606 ***	0.000003790	ND< 0.000002610	0.000003200 **#	NC	NC
123678-HxCDF	0.000005172 ***	0.000001532	0.000001181	0.000001357 **	NC	NC
123789-HxCDF	0.000004422	0.000003898	0.000002942	0.000003754	0.000000751	0.000001865
234678-HxCDF	ND< 0.000000847	ND< 0.000000539	ND< 0.000001062	0.000000816 #	0.000000263	0.000000653
1234678-HpCDF	ND< 0.000050300	ND< 0.000033894	ND< 0.000051884	0.000045359 #	0.000009961	0.000024747
1234789-HpCDF	ND< 0.000004102	0.000003086	0.000002593	0.000003260 #	0.000000770	0.000001912
OCDF	0.000017136	0.000024123	0.000014145	0.000018468	0.000005120	0.000012721
Total TCDD	ND< 0.000000758	0.000008882	ND< 0.000000929	0.000003523 #	0.000004642	0.000011532
Total PeCDD	ND< 0.000000669	0.000007371	ND< 0.000001681	0.000003240 #	0.000003613	0.000008975
Total HxCDD	0.000006080	ND< 0.000001167	ND< 0.000001062	0.000002770 #	0.000002868	0.000007124
Total HpCDD	0.000017112	0.000018065	0.000014803	0.000016660	0.000001677	0.000004167
Total TCDF	0.000005467	0.000005931	*ND< 0.000001062	0.000004153 #	0.000002687	0.000006676
Total PeCDF	ND< 0.000001695	0.000001774	ND< 0.000000663	0.000001377 #	0.000000619	0.000001539
Total HxCDF	0.000025204	0.000016386	0.000005484	0.000015692	0.000009878	0.000024541
Total HpCDF	0.000006264	0.000011702	0.000009355	0.000009107	0.000002727	0.000006776

*Indicates subtraction of train blank reduced concentration to 0.

**Average does not include samples with unacceptable recoveries.

***Indicates recovery for individual internal standard is less than 50 percent.

NC = Not calculated.

#Indicates average emission factor calculated from one or more non-detect values.

TABLE V-10. EMISSION FACTORS FOR DIOXINS/FURANS EXITING SNRB™ (lb/10E12 BTU)

ANALYTE	Location 7 - SNRB™ Outlet R1-L7	R2-L7	R3-L7	Average	Standard Deviation	95% Confidence Interval (+/-)
2378-TCDD	ND< 0.000000559	0.000003865	ND< 0.000000872	0.000001765 #	0.000001825	0.000004535
12378-PeCDD	ND< 0.000001066	0.000047753	ND< 0.000001129	0.000016649 #	0.000026936	0.000066919
123478-HxCDD	ND< 0.000000762	0.000114498	ND< 0.000001334	0.000038865 #	0.000065501	0.000162727
123678-HxCDD	ND< 0.000001269	0.000122989	ND< 0.000001180	0.000041813 #	0.000070301	0.000174651
123789-HxCDD	0.000001808	0.000250713	ND< 0.000001745	0.000084755 #	0.000143724	0.000357059
1234678-HpCDD	ND< 0.000007210	0.001487087	0.000008747	0.000501015 #	0.000853964	0.002121535
OCDD	*ND< 0.000012003	0.003961979	*ND< 0.000012003	0.001328662 #	0.002280519	0.005665582
2378-TCDF	0.000003044	0.000111557	0.000002671	0.000039091	0.000062758	0.000155913
12378-PeCDF	ND< 0.000002488	0.000091245	ND< 0.000001232	0.000031655 #	0.000051610	0.000128218
23478-PeCDF	0.000001929	0.000172471	0.000001404	0.000058601	0.000098615	0.000244992
123478-HxCDF	0.000009850 ***	0.002899784 ***	0.000003439	0.000003439 **	NC	NC
123678-HxCDF	ND< 0.000003859 ***	0.000443236 ***	0.000001159	0.000001159 **#	NC	NC
123789-HxCDF	0.000003406	0.000620997	0.000002400	0.000208934	0.000356857	0.000886554
234678-HxCDF	ND< 0.000000609	0.000038754	ND< 0.000000924	0.000013429 #	0.000021933	0.000054488
1234678-HpCDF	ND< 0.000030972	0.003275681	ND< 0.000041513	0.001116055 #	0.001870298	0.004646453
1234789-HpCDF	ND< 0.000001879	0.000442885	0.000001710	0.000148825 #	0.000254664	0.000632671
OCDF	0.000005100	0.001974978	0.000004985	0.000661688	0.001137343	0.002825544
Total TCDD	ND< 0.000000559	0.000028509	ND< 0.000000872	0.000009980 #	0.000016048	0.000039867
Total PeCDD	ND< 0.000001066	0.000177671	ND< 0.000001129	0.000059955 #	0.000101945	0.000253265
Total HxCDD	0.000001808	0.000923365	ND< 0.000001334	0.000308836 #	0.000532198	0.001322159
Total HpCDD	ND< 0.000007210	0.002616399	0.000014441	0.000879350 #	0.001504333	0.003737272
Total TCDF	0.000009266	0.000232330	0.000008304	0.000083300	0.000129065	0.000320640
Total PeCDF	0.000001929	0.000796439	0.000002765	0.000267044	0.000458469	0.001138993
Total HxCDF	0.000013250	0.006616142	0.000006997	0.002212130	0.003813988	0.009475236
Total HpCDF	ND< 0.000030972	0.004506016	0.000004321	0.001513770 #	0.002591396	0.006437904

*Indicates subtraction of train blank reduced concentration to 0; estimated detection limit is provided.
**Average does not include samples with unacceptable recoveries.
***Indicates recovery for individual internal standard is less than 50 percent.
#Indicates average emission factor calculated from one or more non-detect values.
NC = Not calculated.

VI. CONTROL EQUIPMENT REMOVAL EFFICIENCIES

Removal efficiencies for particulate matter and trace substances were calculated using measured concentrations of substances corrected for field blank levels. These calculations are reported for those substances for which the calculations are meaningful as a group. Sample calculations can be found in Appendix D, with a summary of results in Appendix E. Results are presented in Tables VI-1 to VI-3 for ash and elements. Particulate matter removal efficiencies for the ESP and SNRB™ system are shown in Table VI-1.

Tables VI-2 and VI-3 show removal efficiencies for the ESP and the SNRB™ process for 13 metals. Removal efficiencies through the ESP process were calculated using Location 2 data as the inlet concentration.

The removal efficiencies for metals may be low because the material balance calculations pointed to reporting of low concentrations of metals in the flue gas leaving the boiler (inlet to the ESP Location 10 and SNRB™ Location 2). If these inlet concentrations of metals are low, then the calculated efficiencies for metals across the ESP and SNRB™ are also low. Nevertheless the results of the calculations show that for all metals except mercury and selenium, there was a reduction of emissions of elements of more than 95 percent in the ESP. The average removal efficiencies for mercury and selenium were -27 and 74 percent, respectively.

For all metals except mercury, cadmium, nickel, and antimony, there was a reduction in flue gas concentration in excess of 97 percent through the SNRB™ process. The reductions for mercury, cadmium, nickel, and antimony were calculated to be 0, 66, 75, and 90 percent. For six of the metals, the removal efficiency of the SNRB™ process was equal to or greater than that of the ESP. No beryllium emissions were detected exiting either the ESP or SNRB™ process.

If, as suspected, the metals content of the flue gas stream exiting the boiler is underreported, the removal efficiencies for both the ESP and the SNRB™ process would have been greater than the values shown in both Tables VI-2 and VI-3.

TABLE VI-1. REMOVAL EFFICIENCIES OF THE ESP AND SNRB™ FOR PARTICULATE MATTER[(a)]

Control System	4/26/93	5/1/93	5/2/93	Average	Standard Deviation	95% Confidence Interval (±)
ESP[(b)]	99.18	99.07	99.62	99.29	0.29	0.72
SNRB™[(c)]	99.37	99.56	99.8	99.57	0.22	0.93

(a) Values given in percent.
(b) Using Location 2 as inlet condition.
(c) SNRB™ process overall; the baghouse collection efficiency would be higher.

TABLE VI-2. REMOVAL EFFICIENCIES OF THE ESP FOR METALS (BASED ON LOCATION 2 DATA)

	Removal Efficiency (percent)					
Metal	4/27/93	4/29/93	4/30/93	Average	Standard Deviation	95% Confidence Interval (±)
Mercury	-60[(a)]	-33	12.4	-27	37	91.92
Chromium	99.97	99.13	99.91	99.67	0.47	1.16
Cadmium	100[(b)]	100	100	100	0.00	0.00
Nickel	100	99.83	100	99.94	0.10	0.24
Barium	100	99.5	100	99.83	0.29	0.72
Cobalt	100	100	100	100	0.00	0.00
Manganese	99.91	85.45	99.79	95.05	8.31	20.65
Vanadium	100	99.48	99.98	99.82	0.29	0.73
Beryllium	100	100	100	100	0.00	0.00
Arsenic	99.61	97.69	99.65	98.98	1.12	2.78
Lead	100	99.84	100	99.95	0.09	0.23
Antimony	98.56	99.01	99.71	99.09	0.58	1.44
Selenium	37.10	92.35	93.80	74.43	32.00	79.50

(a) A negative value indicates outlet concentration exceeded inlet concentration. When a negative value occurred, a value of zero was used in determining average, standard deviation, and confidence intervals.
(b) 100 indicates that the metal was not detected or was not detected at a level greater than the field blank in the outlet stream.

TABLE VI-3. REMOVAL EFFICIENCIES OF SNRB™ FOR METALS

	Removal Efficiency (percent)					
Metal	4/27/93	4/29/93	4/30/93	Average	Standard Deviation	95% Confidence Interval (±)
Mercury	-123.8[a]	-75.7	-33.8	-77.8	NC	NC
Chromium	100[b]	95.1	100	98.4	2.83	7.03
Cadmium	94.4	5.8	98.2	66.2	52.28	129.89
Nickel	98.99	26.4	100	75.1	42.20	104.85
Barium	100	99.95	100	99.98	0.03	0.07
Cobalt	100	92.5	100	97.5	4.33	10.76
Manganese	100	99.33	99.98	99.77	0.38	0.95
Vanadium	100	100	100	100	0	0
Beryllium	100	100	100	100	0	0
Arsenic	NS[c]	99.12	99.95	99.53	NC[d]	NC
Lead	NS	99.03	100	99.51	NC	NC
Antimony	NS	79.6	100	89.8	NC	NC
Selenium	NS	100	100	100	NC	NC

(a) A negative value indicates outlet concentration exceeded inlet concentration. When a negative value occurred, a value of zero was used in determining average, standard deviation, and confidence intervals.

(b) 100 indicates that the metal was not detected or was not detected at a level greater than the field blank in the outlet stream.

(c) NS indicates no sample data.

(d) NC indicates not calculated because only two data points or because the result would not be meaningful.

Table VI-4 reports removal efficiencies through the ESP and SNRB™ process for fluoride and chloride. The data indicate that the ESP did not remove any fluoride or chloride, and the outlet concentrations were measured to be greater than the inlet concentrations. The SNRB™ process removed 84 percent of the fluoride and 96 percent of the chloride.

TABLE VI-4. REMOVAL EFFICIENCIES OF THE ESP AND SNRB™ FOR FLUORIDE/CHLORIDE

	Removal Efficiency (percent)						
Substance	System[b]	4/27/93	4/29/93	4/30/93	Average	Standard Deviation	95% Confidence Interval (±)
Fluoride	ESP	-25.4[a]	-162	-28	NC[c]	NC	NC
Fluoride	SNRB™	53.4	100	99.14	84.2	26.7	114.8
Chloride	ESP	-343	8.2	-5.5	NC	NC	NC
Chloride	SNRB™	91.5	97.2	99.99	96.2	4.4	18.8

(a) A negative value indicates outlet concentration exceeded inlet concentration.

(b) Using Location 2 as inlet concentration.

(c) NC indicates not calculated because the result would not be meaningful.

VII. DATA EVALUATION

A. Process Operations Assessment

The boiler and SNRB™ system were operated within the allowable range of parameters (Tables II-2 and II-3) except ammonia feed rate for the test. Selected operating parameters are summarized in Tables VII-1 to VII-3. Daily averages were computed from readings taken at half-hour intervals for the boiler and half-hour intervals on the first day and 45-minute intervals on succeeding days for the SNRB™ system. Process data sheets, with individual data for the selected parameters presented in Tables VII-1 to VII-3 and other parameters, are presented in Appendix F.

For the boiler, the daily average generation rate ranged between 150.7 and 152.5 MW, with a maximum daily standard deviation of 2.8 MW. The daily average steam generation rates ranged between 1.128 and 1.139 x 10^6 pounds of steam per hour. The daily average excess oxygen ranged between 3.23 and 3.55 percent.

Average measured flue gas conditions at the five flue gas sampling locations are listed in Table VII-4. The standard deviations are shown in parentheses. Measured flue gas temperature, moisture, and flow during metals and SVOC sampling are quite uniform. Greater variation relative to the mean is seen in the mass loading data.

The ESP also operated at essentially steady-state conditions throughout the test as evidenced by periodic measurements of voltages and currents.

The only problem that was encountered with the boiler system during the test was numerous times that a pin on a mill was sheared disrupting the coal feed rate. When this occurred, a pulverizer was taken out of service temporarily, and the unit load dropped a little. When a pulverizer was taken out of service, sampling was suspended until about five minutes after the pulverizer was returned to service. This usually was less than an hour in duration. Some of these events are attributed to the wetness of the coal during the test. Heavy rain occurred the night before the first day of sampling.

TABLE VII-1. PROCESS DATA FOR THE BOILER[a]

Test Date	Generation Rate (MW)	Steam Generation Rate (10E3 lb/hr)	Excess Oxygen (percent)	Coal Feed Rate (ton/hr)[b]
4/26	151.7 (0.90)	1128.6 (5.6)	3.4 (0.33)	63.1
4/27	152.5 (0.63)	1139.1 (7.2)	3.45 (0.36)	63.1
4/29	151.7 (2.32)	1133.2 (22.0)	3.5 (0.77)	63.1
4/30	151 (2.75)	1130.9 (15.7)	3.23 (0.47)	63.1
5/01	151.2 (1.51)	1128.6 (8.5)	3.55 (0.46)	63.1
5/02	150.7 (0.66)	1127.6 (8.6)	3.43 (0.54)	63.1

(a) Values given are averages and standard deviations (in parentheses).

(b) Average for test period.

TABLE VII-2. PROCESS DATA FOR THE SNRB™ PROCESS: OPERATING CONDITIONS[a]

	Excess Oxygen (%)			Feed Rate (lb/hr)	
Test Date	SNRB™ Inlet	Baghouse Inlet	Baghouse Outlet	Sorbent	Ammonia
4/26	4.51 (0.35)	4.41 (0.21)	5.75 (0.36)	476	9*[b]
4/27	4.55 (0.55)	4.45 (0.36)	5.64 (0.33)	450	9.5*
4/29	4.35 (0.25)	4.12 (0.23)	5.35 (0.22)	441 (24)	9.4* (0.5)
4/30	4.7 (0.24)	4.4 (0.22)	5.52 (0.20)	458 (8.3)	9.5* (0.4)
5/01	4.65 (0.21)	4.45 (0.16)	5.67 (0.16)	451 (25)	8.3* (0.5)
5/02	4.65 (0.12)	4.07 (0.16)	5.55 (0.20)	471 (8.2)	9.9* (0.3)

(a) Values given are averages and standard deviations (in parentheses).

(b) Asterisk indicates the value of the parameter was outside of the expected value for SNRB™ operation (given in Table II-2). This results from the higher than expected baghouse inlet NO_x concentration (see Table VII-3).

TABLE VII-3. PROCESS DATA FOR THE SNRB™ PROCESS: EMISSIONS[a]

Test	SO2 Emissions (ppm)			NOx Emissions (ppm)		
Date	SNRB™ Inlet	Baghouse Inlet	Baghouse Outlet	SNRB™ Inlet	Baghouse Inlet	Baghouse Outlet
4/26	2525	2111	207	521	427	42
	(84)	(56)	(66)	(180)	(13)	(10.2)
4/27	2299	1968	206	524	427	35.7
	(79)	(85)	(53)	(191)	(15)	(9.8)
4/29	2252	1915	296	476	381	32.7
	(117)	(90)	(101)	(37)	(37)	(10.8)
4/30	2303	1910	232	505	407	37
	(75)	(55)	(27)	(33)	(28)	(10.7)
5/01	2302	1941	250	523	439	29
	(116)	(111)	(76)	(15)	(7.9)	(7.7)
5/02	2401	2101	252	515	427	30.5
	(58)	(33)	(53)	(10)	(8.8)	(5.0)

(a) Values given are averages and standard deviations (in parentheses).

TABLE VII-4. AVERAGE FLUE GAS CONDITIONS AT LOCATIONS 2, 5, 7, 10, 12

Location	Temperature (°F)	Moisture (%)	Particulate Loading (mg/dscm)	Flow Rate (m/s)
2	639 (4)	8.3 (1.8)	8,500 (1,760)	13.2 (0.4)
5	865 (8)	8.6 (0.6)	19,800 (5,380)	14.5 (1.1)
7	793 (3)	7.1 (1.5)	28 (9)(a)	16.0 (0.8)
10	317 (0.8)	7.9 (0.4)	8,980 (774)	23.2 (0.6)
12	321 (3)	7.7 (0.3)	52 (13)	23.8 (0.4)

(a) One of three runs does not have a filter weight included (see Table III-2).
(b) Numbers in parentheses are standard deviations.

The SNRB™ system operated steadily throughout the test. Data on excess oxygen, feed rates of sorbent and ammonia, and SO_2 and NO_x concentrations are listed in Tables VII-2 and VII-3. Daily average SO_2 concentrations at the SNRB™ inlet and baghouse outlet ranged from 2,252 to 2,525 ppm and from 206 to 296 ppm, respectively. Daily average NO_x levels at the SNRB™ inlet and baghouse outlet ranged from 476 to 524 ppm and from 29 to 42 ppm, respectively. Although NO_x and SO_x were not measured at the ESP, the SNRB™ inlet numbers may be used as approximate values for the ESP inlet.

B. Sampling Assessment

Method Modifications

In this section, modifications to sampling procedures are described which were deliberately made to improve the quality of the measurements. In most cases, the modifications were made to avoid vertical flue gas sampling (which would have been very difficult at the different locations) or to eliminate or minimize problems due to high flue gas temperature, high dust loading, or high SO_2 concentration. Deviations formally documented in the course of the project are provided in Appendix G.

Method 29 - Trace Metals. EPA Method 29 (draft June 1992) was used to collect samples for determination of trace metals in the flue gas. Quartz or borosilicate glass one-piece probe/nozzle assemblies were used at all locations except as noted below. Several modifications to the standard sampling procedures were necessary for SNRB™ air toxics monitoring. These included:

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the ESP inlet (Location 10). A glass cyclone preceding the filter was used to reduce filter plugging due to the high particulate loading at these locations.

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the SNRB™ outlet (Location 7). Flexible, heated, Teflon sample lines were used to connect the probes to the heated filter box to eliminate the need for vertical sampling imposed by the sample port configuration. These lines were less than 10 feet long. A thermocouple was inserted under the heating sheath to monitor and control line temperature.

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the SNRB™ outlet (Location 7). An air-cooled probe was used because the very high flue gas temperature at these locations -- in excess of 650°F -- would exceed the working temperature of the flexible Teflon sample lines and Teflon filter.

- ESP outlet (Location 12). A Teflon probe liner was used instead of quartz or glass because the length of the probe would have resulted in frequent breakage. A quartz nozzle attached with Teflon fittings was used.

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), ESP inlet (Location 10), and ESP outlet (Location 12). The volume of HNO_3/H_2O_2 solution in impingers 2 and 3 was increased to 500 mL each to prevent depletion due to the high SO_2 concentration in the flue gas.

- An acetone rinse of the probe, cyclone, filter housing, and connecting "front half" glassware was performed and recovered separately with the filter.

<u>Method 26A - HCl, HF, Particulate Matter, and Radionuclides</u>. EPA Method 26A (40 CFR 60, Appendix A, revised December 31, 1992) was used to collect samples for determination of HCl, HF, particulate matter, and radionuclides. The following modifications to sampling procedures were made:

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the ESP inlet (Location 10). A glass cyclone preceding the filter was used to reduce filter plugging due to the high particulate loading at these locations.

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the SNRB™ outlet (Location 7). Flexible, heated, Teflon sample lines were used to connect the probes to the heated filter box to eliminate the need for vertical sampling imposed by the sample port configuration. These lines were less than 10 feet long. A thermocouple was inserted under the heating sheath to monitor and control line temperature.

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the SNRB™ outlet (Location 7). An air-cooled probe was used because the very high flue gas temperature at these locations -- in excess of 650°F -- would otherwise exceed the working temperature of the flexible Teflon sample lines and Teflon filter.

- ESP outlet (Location 12). A Teflon probe liner was used instead of quartz or glass because the length of the probe would have resulted in frequent breakage. A quartz nozzle attached with Teflon fittings was used.

- The normality of the NaOH solution in impingers 3 and 4 was increased to 0.5N. The volume of solution was maintained at 100 mL.

- An additional impinger containing 200 mL of 10 percent H_2O_2 solution was added prior to the silica gel impinger to remove SO_2/H_2SO_4 and minimize corrosion of the sampling equipment.

- An acetone rinse of the probe, cyclone, filter housing, and connecting "front half" glassware was performed and recovered separately with the filter to enable particulate loading determination (allowed in the method, except at the baghouse inlet (Location 5).

- At the baghouse inlet (Location 5), samples were collected non-isokinetically with the nozzle pointed downstream to minimize buildup of particulate matter on the filter. This was done to reduce the potential for removal of HCl on the filter due to buildup of lime.

Method 5 - Particulate Matter and Radionuclides. At Location 5 only, a separate sample train was used to sample isokinetically for particulate matter and radionuclides using EPA Method 5 procedures.

Method 0010/23 - Semivolatile Organic Compounds. EPA Method 0010 (SW-846) and EPA Method 23 (40 CFR 60, Appendix A, December 31, 1992) were used for determination of semivolatile organic compounds including dioxins and furans. The general procedures of Method 0010 were applied with modifications to incorporate quality assurance/quality control, and sample recovery procedures of Method 23. Modifications to the published sampling procedures included:

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the ESP inlet (Location 10). A glass cyclone preceding the filter was used to reduce filter plugging due to the high particulate loading anticipated at these locations.

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the SNRB™ outlet (Location 7). Flexible, heated, Teflon sample lines were used to connect the probes to the heated filter box to eliminate the need for vertical sampling imposed by the sample port configuration. These lines were less than 10 feet long. A thermocouple was inserted under the heating sheath to monitor and control line temperature.

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the SNRB™ outlet (Location 7). An air-cooled probe was used because the very high flue gas temperature at these locations -- in excess of 650°F -- would otherwise exceed the working temperature of the flexible Teflon sample lines and Teflon filter.

- ESP outlet (Location 12). A Teflon probe liner was used instead of quartz or glass because the length of the probe would have resulted in frequent breakage. A quartz nozzle attached with Teflon fittings was used.

- An additional impinger containing 200 mL of 10 percent H_2O_2 solution was added prior to the silica gel impinger to minimize downtime due to sampling equipment SO_2/H_2SO_4 corrosion.

<u>Method 0011 - Formaldehyde</u>. EPA Method 0011 (June 26, 1990) was used to collect samples for determination of formaldehyde. The sample train did not employ a filter prior to the impingers. The following modifications to the published sampling procedures were made:

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the ESP inlet (Location 10). A glass cyclone preceding the empty filter housing was used to collect particulate matter.

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the SNRB™ outlet (Location 7). Flexible, heated, Teflon sample lines were used to connect the probes to the heated filter box to eliminate the need for vertical sampling imposed by the sample port configuration. These lines were less than 10 feet long. A thermocouple was inserted under the heating sheath to monitor and control line temperature.

- SNRB™ inlet (Location 2), baghouse inlet (Location 5), and the SNRB™ outlet (Location 7). An air-cooled probe was used because the very high flue gas temperature at these locations -- in excess of 650°F -- would otherwise exceed the working temperature of the flexible Teflon sample lines and Teflon filter.

- ESP outlet (Location 12). A Teflon probe liner was used instead of quartz or glass because the length of the probe would have resulted in frequent breakage. A quartz nozzle attached with Teflon fittings was used.
- An additional impinger containing 200 mL of 10 percent H_2O_2 solution was added prior to the silica gel impinger to remove SO_2/H_2SO_4 and minimize corrosion of the sampling equipment.

Method 18 - Gaseous Organic Compounds. EPA Method 18 (40 CFR 60, Appendix A, February 13, 1991) was used to collect samples for determination of gaseous organic compounds. Tedlar bags (15-L) were filled over a 30-minute period using a lung sampler system. No modifications to the published sampling procedures were made.

Particle Size - Series Cyclones. A 5-stage series cyclone sampler design developed at Southern Research Institute was used to determine the particle size distribution in the flue gas at the SNRB™ baghouse inlet (Location 5) and the ESP inlet (Location 10). Sampling procedures followed the manufacturer's instruction manual. Samples were collected isokinetically from a single representative sampling point in the ducts.

Particle Size - Cascade Impactors. Andersen Mark III cascade impactors were used to determine particle size distribution in the flue gas at the SNRB™ baghouse outlet (Location 7) and the ESP outlet (Location 12). Sampling procedures followed procedures outlined in "Procedures for Cascade Impactor Calibration and Operation in Process Streams" (EPA 600/2-77-004). Reeve-Angel filter substrates were used to avoid sulfate interference in the measurements. Samples were collected isokinetically at a single representative sampling point in the ducts.

Process Solids Sampling. Samples of solids entering and leaving the process were collected following procedures outlined in SW-846 and ASME Performance Test Code 2. No major modifications were necessary.

Sampling Considerations

The following discussion summarizes events or conditions encountered at each sampling location as they influence the potential quality of the data. A common problem to all of the high temperature flue gas sampling locations was frequent plugging of the Method 29 train filters. This is believed to be due to partial melting of the Teflon filter substrates. The impact of this on the data is that frequent filter changes were required, resulting in extension of the testing periods and decreased overlap in the sampling period with other measurements. Also, it meant that more than one filter had to be handled in the field and laboratory for the time period of sampling. This is not expected to influence the data significantly.

Location 1 - Coal Feed. Pulverized coal samples were collected by Burger plant personnel using the International Standards Organization (ISO) rotary probe method (ISO Draft Standard ISO/TC27/SC 4/WG 3N10). Ten out of a total of 20 burner pipes were sampled, and the samples were composited. No problems were encountered with the collection of these samples.

Location 2 - Flue Gas/SNRB™ Inlet.

- Silicon grease was mistakenly applied to the Method 29 sampling train of Run 2 by the operator to overcome leak problems. This may have caused contamination of the sample with silicon, an interferant in sample analysis. The amount of contamination is believed to be small because the grease was observed upon breakdown of the train by the recovery team and efforts to minimize contamination were employed.

- Condensate was observed in the sample line and rotameter of the Method 18 run of April 29 (Run 1). This may have resulted in loss of some of the soluble gaseous organic compounds from the sample.

- Part of the probe rinse of the Method 0010/23 train was mixed with the probe rinse for the SNRB™ baghouse inlet (Location 5) due to a sample recovery error in Run 2. After concurrence with B&W, this combined rinse (Sample No. 156408) was not analyzed but was placed in archival storage. The impact of this error on the sample results cannot be determined absolutely, although a low bias in the results for this location would be expected if any.

<u>Location 3 - Sorbent Feed</u>. No problems were encountered.

<u>Location 4 - Ammonia Feed</u>. No sampling activities were planned at this location.

<u>Location 5 - Flue Gas/Baghouse Inlet</u>.

- Condensate was observed in the sample line and rotameter of the Method 18 run of April 29 (Run 1). This may have resulted in loss of some of the soluble gaseous organic compounds from the sample.

- Part of the probe rinse of the Method 0010/23 train from the SNRB™ inlet (Location 2) was mixed with the probe rinse for this location due to a sample recovery error in Run 2. After concurrence with B&W, this combined rinse (Sample No. 156408) was not analyzed but was placed in archival storage. The impact of this error on the sample results cannot be determined absolutely, although a low bias in the results for this location would be expected if any.

<u>Location 6 - SNRB™ Solids</u>. No problems were encountered.

<u>Location 7 - Flue Gas/SNRB™ Outlet</u>.

- The filter in the Run 1 Method 29 train was dislodged from the Teflon frit. This may have resulted in some particulate matter entering the impingers. This is not expected to affect the data since determination of solid-gas partitioning was not a project objective and particulate matter was not determined with the Method 29 train.

- The cascade impactor train of Run 1 appeared to have been backflushed slightly. Some sample filters were wet upon recovery. This may bias the results slightly. Since the particulate loading is very low and few large particles are expected at this location, the bias is expected to be towards the smaller particles rather than the larger.

- A bag leak may have developed during the Method 18 run on April 29 (Run 1). This may have diluted the sample with ambient air. Assuming that ambient concentrations of target substances are negligible, this is expected to cause dilution of the sample only and measured concentrations would be less than actual.

- For mercury speciation sampling at the SNRB™ outlet, the samples showed oxidized mercury breakthrough into the second soda lime trap (backup trap). Breakthrough may have occurred because of the unusually high flue gas sampling temperatures (825°F). The elevated temperature may result in elevated sorbent temperatures for the first two traps (soda lime), which entend into the flue gas (ref 3). The traps should be maintained at 212-248°F. Elevated sorbent temperatures can cause the analyte to migrate. Thus, for the SNRB™ results, the oxidized forms of mercury should be considered suspect (possible minimum values). The value for total mercury is not affected by the sorbent breakthrough.

<u>Location 8 - Bottom Ash</u>. No problems were encountered.

<u>Location 9 - ESP Ash</u>. No problems were encountered.

<u>Location 10 - Flue Gas/ESP Inlet</u>.

- Sampling could not be performed through two of the five sampling ports due to interferences preventing the long sampling probe to be inserted. Sampling was performed at 8 points through each of the 3 ports for a total of 24 points. This may bias solid-phase results if the composition or concentration of dust in the duct is not uniformly distributed. The possible magnitude of the bias cannot be determined. It may also bias the gas-phase results; however, since this location is relatively far downstream, the magnitude of the bias is probably small after accounting for dilution.

- The Method 29 sample trains for Runs 1 and 2 were slightly backflushed, causing some of the condensate from the first impinger to enter the filter housing. The other impingers did not appear affected. No impact on data quality is expected because the amount of condensate involved was minimal.

- The Method 0011 sample trains for Runs 1 and 2 were backflushed slightly, causing some of the DNPH solution to enter the filter housing.

Location 11 - Collected Fly Ash. No problems were encountered.

Location 12 - Flue Gas/ESP Outlet.

- Condensate was observed in the sample line and rotameter of the Method 18 run of April 27 (Run 1). This may have resulted in loss of some of the soluble gaseous organic compounds from the sample.
- The Method 0010/23 train was backflushed during a leak check between sample ports on May 1 (Run 3).

Isokinetic Summaries

Calculations were performed to document the extent to which isokinetic was conducted as called for in the QAPP. The results of these calculations are shown in Table VII-5. Perfect isokinetic sampling would be 100 percent.

Field Sampling Audit

An audit of the field sampling activities conducted by EER was performed by Mr. William Baytos of Battelle as an independent check of field sampling procedures. No major findings were observed in this audit. The report from this audit is provided in Appendix H.

C. Laboratory Assessment

Summaries of the quality control data reported and precision and accuracy results are provided in Tables VII-6 and VII-7, respectively. Laboratory deviations formally documented during the course of the study are presented in Appendix G.

TABLE VII-5. ISOKINETIC SUMMARIES

Sample Train/Run	Test Date	Location 2	Location 5	Location 7	Location 10	Location 12
SVOC-1	4/26/93	101.88	101.24	96.03	100.28	100.97
SVOC-2	4/28/93	104.03	97.29	101.22	101.11	101.77
SVOC-3	5/1/93	97.33	100.91	101.42	97.88	100.12
Metals-1	4/27/93	107.30	101.04	100.77	99.63	97.87
Metals-2	4/29/93	106.13	100.02	97.89	100.77	101.13
Metals-3	4/30/93	103.47	103.39	99.51	93.02	101.50
HCl/PART-1	4/26/93	102.12	-	100.64	96.07	101.58
HCl/PART-2	5/1/93	103.42	-	103.95	99.90	102.98
HCl/PART-3	5/2/93	100.89	-	100.16	96.23	98.32
PART-1(a)	4/26/93	-	105.21	-	-	-
PART-2	5/1/93	-	100.77	-	-	-
PART-3	5/2/93	-	96.30	-	-	-
Formaldehyde-1	4/26/93	103.12	106.72	91.99	97.89	99.37
Formaldehyde-2	5/2/93	-	-	97.39	99.58	95.51

(a) The Method 5 train was used to collect particulate matter only at Location 5 instead of a Method 26A (HCl/particle) train.

TABLE VII-6. TYPES OF QUALITY CONTROL DATA REPORTED

Analyte Class/ Sample Matrix	Precision				Accuracy			Blanks			
	Replicate Runs	Duplicate Laboratory Samples	Replicate Spike Recoveries	Daily Calibration	Matrix Spike	Surrogate Recovery	Standard Reference Material	Train Blank	Reagent Blank	Trip Blank	Laboratory Method Blank
Metals											
Gas	+	+ (a)		+	+		+(b)	+			
Solid	+	+		+	+		+				
Chloride/Fluoride											
Gas	+	+ (a)		+			+(b)	+	+		
Solid	+	+ (a)		+	+						
PAH											
Gas	+		+	+		+		+			+
Dioxins/Furans											
Gas	+		+	+	+	+		+			+
Carbonyls											
Gas	+			+	+			+	+		
VOC											
Gas	+	+ (a)		+	+					+	

(a) Water SRM used to simulate impinger solutions.
(b) Duplicate instrument analysis only.

TABLE VII-7. SUMMARY OF PRECISION AND ACCURACY RESULTS

Analyte Class/ Sample Matrix	Accuracy			Precision		
	How Measured	Target Objective (%)	Actual (a) (%)	How Measured	Target Objective (%)	Actual (a) (%)
Metals in Gas Samples by ICP-AES	Spike Recovery			RPD of Duplicate Samples		
Chromium		75-125	99-106		<10	0.09, 8
Cadmium		75-125	105		<10	0, 5
Nickel		75-125	99-105		<10	0.7, 46 (b)
Barium		75-125	96-103		<10	1, 39 (b)
Cobalt		75-125	99-103		<10	18, 45(b)
Manganese		75-125	95-103		<10	0.1, 6
Vanadium		75-125	93-99		<10	0, 21
Beryllium		75-125	95-103		<10	2, 5
Metals in Solid Samples by ICP-AES	Spike Recovery			RPD of Duplicate Samples		
Chromium		75-125	90, 97		<10	1, 3
Cadmium		75-125	83, 86		<10	10, 2
Nickel		75-125	84, 88		<10	9, 2
Barium		75-125	77, 82		<10	8, 2
Cobalt		75-125	81, 104		<10	2, 9
Manganese		75-125	81, 86		<10	2, 9
Vanadium		75-125	78, 84		<10	2, 1
Beryllium		75-125	82, 87		<10	0.7, 1
Metals in Gas Samples by GF-AAS	Spike Recovery			RPD of Duplicate Samples		
Arsenic		75-125	74-109		<10	5.3 - 21 (c)
Selenium		75-125	72-110		<10	0.9 - 22
Lead		75-125	78-116		<10	6 - 19
Antimony		75-125	77-101		<10	18, 23
Metals in Solid Samples by GF-AAS	Spike Recovery			RPD of Duplicate Samples		
Arsenic		75-125	78-107		<10	11, 17
Selenium		75-125	94-108		<10	2.4 - 98
Lead		75-125	84-120		<10	2.8
Antimony		75-125	87-109		<10	7, 29

(a) Except where indicated, range represents range of results for multiple samples, two numbers separated by comma represents results for two samples, and single number represents result for single sample.
(b) Result for sample with concentrations at or below detection limit.
(c) Excludes outliers of 3000, 176, and 65% RPD for three samples with concentrations at or below detection limit.
(d) Outlier of 34 percent not included.
(e) Results fall within acceptable concentration range for SRM.
(f) Accuracy and precision results for PAH and dioxins/furans are averages of multiple sample results.
(g) PAH results within parentheses are averages excluding samples with poor extraction efficiency due to high particulate loading.
(h) Dioxin/furan average results exclude samples with poor extraction efficiency due to high particulate loading.
(i) NA = Not applicable since analytes not detected in samples.

TABLE VII-7. (Continued)

Analyte Class/ Sample Matrix	Accuracy How Measured	Accuracy Target Objective (%)	Accuracy Actual [a] (%)	Precision How Measured	Precision Target Objective (%)	Precision Actual [a] (%)
Mercury in Gas Samples by CV-AAS	Spike Recovery	75-125	90-120 (d)	RPD of Duplicate Samples	<10	0 - 33
Mercury in Solid Samples by CV-AAS	Spike Recovery	75-125	100-106	RPD of Duplicate Samples	<10	0 - 5
Chloride/Fluoride in Gas Samples by IC	SRM Recovery			RPD of Duplicate Samples		
Chloride		75-125	(e)		<10	2.8
Fluoride		75-125	(e)		<10	2.8
Chloride/Fluoride in Solid Samples by IC	Spike Recovery			RPD of Duplicate Samples		
Chloride		75-125	105		<10	9.5
Fluoride		75-125	97		<10	3.9
PAH in Gas Samples by GC/MS (f)	Spike Recovery			RSD of Replicate Spike Recoveries		
d12-Benzo(k)fluoranthene		50-120	55 (66) (g)		<30	37 (12) (g)
d12-Benzo(e)pyrene		50-120	55 (62) (g)		<30	36 (15) (g)

(a) Except where indicated, range represents range of results for multiple samples, two numbers separated by comma represents results for two samples, and single number represents result for single sample.
(b) Result for sample with concentrations at or below detection limit.
(c) Excludes outliers of 3000, 176, and 65% RPD for three samples with concentrations at or below detection limit.
(d) Outlier of 34 percent not included.
(e) Results fall within acceptable concentration range for SRM.
(f) Accuracy and precision results for PAH and dioxins/furans are averages of multiple sample results.
(g) PAH results within parentheses are averages excluding samples with poor extraction efficiency *due to high particulate loading.*
(h) Dioxin/furan average results exclude samples with poor extraction efficiency due to high particulate loading.
(i) NA = Not applicable since analytes not detected in samples.

TABLE VII-7. (Continued)

Analyte Class/ Sample Matrix	Accuracy How Measured	Target Objective (%)	Actual [a] (%)	Precision How Measured	Target Objective (%)	Actual [a] (%)
Dioxins/Furans in Gas Samples by GC/MS (f,h)	Spike Recovery			RSD of Replicate Spike Recoveries		
2378-TCDD-13C12		40-120	91		<40	10
12378-PeCDD-13C12		40-120	86		<40	25
123478-HxCDD-13C12		40-120	79		<40	28
123678-HxCDD-13C12		40-120	85		<40	27
1234678-HpCDD-13C12		40-120	74		<40	17
OCDD-13C12		40-120	59		<40	23
2378-TCDF-13C12		40-120	73		<40	10
12378-PeCDF-13C12		40-120	59		<40	32
23478-PeCDF-13C12		40-120	68		<40	23
123478-HxCDF-13C12		40-120	36		<40	84
123678-HxCDF-13C12		40-120	40		<40	72
123789-HxCDF-13C12		40-120	66		<40	13
234678-HxCDF-13C12		40-120	68		<40	15
1234678-HpCDF-13C12		40-120	55		<40	35
1234789-HpCDF-13C12		40-120	58		<40	27
2378-TCDD-37Cl4		40-120	97		<40	4
Carbonyls in Gas Samples by HPLC	Spike Recoveries			RSD of Triplicate Samples		
Formaldehyde		80-120	114-122		<10	NA (i)
Acetaldehyde		80-120	85-90		<10	NA
Propionaldehyde		80-120	89-95		<10	NA
Crotonaldehyde		80-120	92-99		<10	NA
Butyraldehyde		80-120	89-91		<10	NA
Benzaldehyde		80-120	110-133		<10	NA

(a) Except where indicated, range represents range of results for multiple samples, two numbers separated by comma represents results for two samples, and single number represents result for single sample.
(b) Result for sample with concentrations at or below detection limit.
(c) Excludes outliers of 3000, 176, and 65% RPD for three samples with concentrations at or below detection limit.
(d) Outlier of 34 percent not included.
(e) Results fall within acceptable concentration range for SRM.
(f) Accuracy and precision results for PAH and dioxins/furans are averages of multiple sample results.
(g) PAH results within parentheses are averages excluding samples with poor extraction efficiency due to high particulate loading.
(h) Dioxin/furan average results exclude samples with poor extraction efficiency due to high particulate loading.
(i) NA = Not applicable since analytes not detected in samples.

TABLE VII-7. (Continued)

Analyte Class/ Sample Matrix	Accuracy: How Measured	Accuracy: Target Objective (%)	Accuracy: Actual [a] (%)	Precision: How Measured	Precision: Target Objective (%)	Precision: Actual [a] (%)
VOC in Gas Samples by GC/MS	Spike Recoveries			RPD of Duplicate Samples		
trichlorofluoromethane		80-120	90		<10	12.2
1,1-dichloroethene		80-120	89		<10	9.5
dichloromethane		80-120	86		<10	18.4
3-chloropropene		80-120	106		<10	10.6
1,1,2-trichloro-1,2,2-tri-fluoroethane		80-120	88		<10	5.5
1,1-dichloroethane		80-120	93		<10	12.2
cis-1,2-dichloroethene		80-120	95		<10	40.7
trichloromethane		80-120	93		<10	13.9
1,2-dichloroethane		80-120	92		<10	2.9
1,1,1-trichloroethane		80-120	87		<10	2.8
benzene		80-120	83		<10	12.9
carbon tetrachloride		80-120	96		<10	11.6
1,2-dichloropropane		80-120	87		<10	10.3
trichloroethene		80-120	94		<10	3.3
cis-1,3-dichloropropene		80-120	85		<10	18.4
trans-1,3-dichloropropene		80-120	82		<10	18.0
1,1,2-trichloroethane		80-120	80		<10	9.3
toluene		80-120	77		<10	4.1
1,2-dibromoethane		80-120	86		<10	9.1
tetrachloroethene		80-120	86		<10	1.6
chlorobenzene		80-120	98		<10	1.2
ethylbenzene		80-120	78		<10	49.4
m+p-xylene		80-120	85		<10	28.7
styrene		80-120	69		<10	10.7
1,1,2,2-tetrachloroethane		80-120	75		<10	9.7
o-xylene		80-120	74		<10	2.7
4-ethyl toluene		80-120	119		<10	50.1
1,3,5-trimethylbenzene		80-120	119		<10	12.0
1,2,4-trimethylbenzene		80-120	83		<10	26.2
benzyl chloride		80-120	41		<10	51.2
m-dichlorobenzene		80-120	61		<10	70.1
p-dichlorobenzene		80-120	91		<10	31.1
o-dichlorobenzene		80-120	68		<10	31.1
1,2,4-trichlorobenzene		80-120	35		<10	4.3
hexachlorobutadiene		80-120	39		<10	8.4

(a) Except where indicated, range represents range of results for multiple samples, two numbers separated by comma represents results for two samples, and single number represents result for single sample.
(b) Result for sample with concentrations at or below detection limit.
(c) Excludes outliers of 3000, 176, and 65% RPD for three samples with concentrations at or below detection limit.
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(e) Results fall within acceptable concentration range for SRM.
(f) Accuracy and precision results for PAH and dioxins/furans are averages of multiple sample results.
(g) PAH results within parentheses are averages excluding samples with poor extraction efficiency due to high particulate loading.
(h) Dioxin/furan average results exclude samples with poor extraction efficiency due to high particulate loading.
(i) NA = Not applicable since analytes not detected in samples.

1. Trace Elements

QAPP and Method Deviations

Alterations to Method 29 for gas emission samples, to SW-846 Methods 7000, 7470, 7471, and 6010 for solid samples, and to procedures specified in the QAPP include the following:

- NIST standard reference material 1632b Coal Ash was not analyzed as a quality control sample because this SRM was not available from NIST at the time sample analyses were conducted.

- In digesting Method 29 samples in preparation for analysis by GF-AAS, perchloric acid was not used as noted in the QAPP. Method 29 only indicates use of nitric acid during the sample digestion. No impact is anticipated because perchloric acid is generally used for decomposition of organics and no significant concentration of organics is thought to be present in the impinger solutions. Digestion with nitric and hydrofluoric acids is expected to be sufficient for digestion of these samples.

- The fourth impinger rinse, permaganate impinger solutions, and 8N HCl rinse of the permaganate impingers were combined in preparation for mercury determination. A 10 mL aliquot was removed after recording the combined sample volume, and prepared according to EPA SW-846 Method 7470 for mercury analysis.

- EPA SW-846 Method 7470 for cold vapor atomic absorption spectrometry (CV-AAS) analysis of mercury does not make mention of the use of silver amalgamation which was used as an enhancement to the cold vapor method, however the analysis of samples for mercury followed Method 7470 in all other technical ways. Incorporation of the silver wool amalgamation improves overall method sensitivity and is expected to have no negative effect on the analytical outcome.

- Cadmium was analyzed by ICP-AES instead of GF-AAS as noted in the QAPP. The levels of cadmium in the Method 29 gas emission samples and solid process samples originally measured with GF-AAS were considered to be too high for the GF-AAS instrument, and the analysis was therefore performed by ICP-AES which exhibits sufficient sensitivity for Cd for this analysis.

- Preparation of the front half Method 29 samples (filter and probe rinses) was complicated by the wide variation in filter catch weights collected for the various trains. Very large amounts of filter catch (>25 grams) for several trains yielded a large final volume of the respective digestate. These larger volumes caused a significant difference between the volume originally used to calculate expected detection limits (450 mL) and what were actually generated resulting in an overall apparent increase in the final method detection limit. In addition, the matrix varied significantly between those samples with relatively little catch and those with relatively large amounts of catch. This complicated the analysis by preventing a closer match between the matrix used for instrument calibration and the actual sample matrix.

- The composited front half Method 29 sample from Run 1 at Location 7 (SNRB™ outlet) was lost during laboratory preparation. The total metals result from that particular train will be low by not being able to include the front half contribution.

- During preparation of the front half from the Method 29 samples, the filter field reagent blank, acetone field reagent blank, and 0.1N HNO_3 field reagent blank were inadvertently combined with the laboratory acid blank. This action prevented the differentiation between the field and laboratory blanks for the Method 29 front half analyses. Consequently, subtraction of front half reagent blank data from samples may not be appropriate. Manganese in the front half reagent blank was detected at a slightly elevated level for an unknown reason. Likewise, the 8N HCl, $KMnO_4$, and 5% HNO_3/10% H_2O_2 field reagent blanks were combined and analyzed for mercury only as a blank for the $KMNO_4$ impingers rather than analyzed separately. As a result, data for a back half field reagent blank for all elements, excluding mercury, are not available. Field reagents were incorporated into the train blanks processed with the Method 29 samples. Subtraction of train blanks from sample results can correct for background contamination introduced by field reagents. The train blanks showed relatively low metal concentrations, relative to the samples, indicating that the field reagents did not introduce spurious contamination to the samples.

- Coal analyses were not conducted by Battelle as stated in the QAPP but were conducted by Commercial Testing and Engineering Co. (CTE).

Calibration Data

The ICP-AES, GF-AAS, and CV-AAS instruments were calibrated before each analysis. The matrix of the calibration standards was chosen to match as closely as possible the digestion matrix of the sample. After calibration, and during analysis, initial calibration verification (ICV) and continuing calibration verification (CCV) standards were run. The percent recovery for the ICV and CCV standards are summarized in Table VII-8 for ICP-AES analysis, Table VII-9 for GF-AAS analysis, and Table VII-10 for CV-AAS analysis.

Results of the calibration verification for ICP-AES analysis were within the QAPP stated guidelines of 100 $\pm$ 25 percent in most cases. Note that these recoveries include correction for the calibration blank results. Instances where particular element recoveries fell outside the limit were evaluated on an individual basis. Some recoveries for cobalt, nickel, and vanadium were greater than 100 $\pm$ 25 percent. The 0.05 ppm ICV standard is the same standard that was used to calibrate the instrument, and the results from the analysis of the 0.05 ppm ICV can be compared to the calculated concentration from the regression. By this comparison, recoveries were determined to be within the QAPP stated limits, and analysis was resumed.

The GF-AAS system, a Perkin-Elmer Model Zeeman 5000, was standardized with a set of 0, 10, 25, 50, 100, or 200 μg/L standard calibration solutions prepared from the method blank solutions for three sets of samples -- Method 29 back-half composites (BHC), Method 29 front-half composites (FHC), and solid samples. After linear calibration was established, the initial calibration verification standards were tested to ensure accuracy and precision of the proper functions of the instrument. The bracket standardizations were performed to compensate the instrument drift. The samples were also spiked to test the recovery as well as to use method of standard addition for matrix correction. Table VII-9 presents the recoveries of the ICV standard with linear correlation coefficient better than 0.999.

Results of the calibration verification for CV-AAS analysis (Table VII-10) were well within the required 100 $\pm$ 25 percent objective.

Accuracy from SRM Analyses

Standard reference materials (SRM) 2676d (Metals on Filter Media), SRM 2677a (Beryllium and Arsenic on Filter Media), SRM 1643c (Trace Elements in Water), and SRM 1633a (Trace Elements in Fly Ash) were analyzed to evaluate analytical accuracy.

Table VII-8. Calibration Results for ICP-AES Analysis

Sample	Cr	Cd	Ni	Ba	Co	Mn	V	Be
Calibration Blank	0.0042	0.0062	0.0026	0.0078	0.0244	0.0015	0.0247	-0.0013
0.05 ppm ICV-1	0.0460	0.0521	0.0461	0.0566	0.0701	0.0507	0.0459	0.0492
% Recovery	84	92	87	98	91	98	42*	101
1.0 ppm CCV	0.9404	0.9439	0.9321	0.9365	0.9488	0.9390	0.9420	0.9334
% Recovery	94	94	93	93	92	94	92	93
Calibration Blank #2	-0.0189	-0.0015	-0.0277	-0.0057	-0.0158	-0.0010	-0.0095	-0.0040
0.05 ppm CCV	0.0320	0.0465	0.0500	0.0459	0.0721	0.0510	0.0597	0.0470
% Recovery	102	96	155*	103	176*	104	138*	102
1.0 ppm CCV	1.0270	0.9689	0.9784	0.9751	0.9811	0.9872	0.9861	0.9935
% Recovery	105	97	101	98	100	99	100	100
Calibration Blank	-0.0007		0.0012	-0.0009	-0.0063	0.0020	-0.0033	0.0024
0.05 ppm ICV	0.0524	0.0536	0.0614	0.0516	0.0562	0.0502	0.0556	0.0495
% Recovery	106	107	120	105	125	96	118	94
1.0 ppm ICV	0.9757	0.1021**	0.9864	0.9586	0.9584	0.9546	0.9586	0.9458
% Recovery	98	102	99	96	96	95	96	94
0.05 ppm CCV	0.0544		0.0573	0.0538	0.0505	0.0518	0.0500	0.0516
% Recovery	110		112	109	114	100	107	98
Calibration Blank	-0.0030		-0.0155	-0.0011	-0.0233	0.0003	-0.0117	0.0021
0.05 ppm CCV	0.0493		0.0468	0.0465	0.0372	0.0493	0.0408	0.0504
% Recovery	105		125	95	121	98	105	97
0.05 ppm CCV	0.0490	0.0469	0.0343	0.0485	0.0408	0.0541	0.0366	0.0496
% Recovery	136*	97	124	108	113	110	92	107
0.1 ppm CCV	0.1063	0.0955	0.0974	0.1038	0.0855	0.1060	0.0950	0.0977
% Recovery	125	97	125	110	101	107	105	102

*Recoveries do not meet target objectives of 100 +/- 25 percent.
**Cd ICV concentration equals 0.100 ppm.

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TABLE VII-9. CALIBRATION RESULTS FOR GF-AAS ANALYSIS

Element	Sample[a,b]	ICV Standard Concentration[c] (μg/L)	Concentration Found[d] (μg/L)	Recovery (%)
As	BHC	10	13.2	132
		25	24.5	98
		50	47.9	95.8
		100	101.7	101.7
	FHC-1	10	9.95	99.5
		25	25.44	101.8
		50	49.92	99.8
	FHC-2	10	11.1	111
		25	26.5	105.8
		50	52.4	104.9
		75	74.8	99.7
	FHC-3	10	12.9	129
		25	27.3	109
		50	50.9	102
	SLD-1	20	16.2	80.9
		50	48.6	97.1
		100	100.5	100.5
		200	198	99
	SLD-2	10	11.6	116
		25	26.6	106
		50	50.9	101.8
		75	78.3	104.4
		100	99.5	99.5
	SLD-3	10	13.4	134
		25	24	96
		50	61.5	122.9
		75	82.6	110.1
		100	110.45	110.5
		200	199.3	99.6

(a) BHC = Method 29 back-half composite, FHC = Method 29 front-half composite, SLD = solid sample.
(b) Sample identification denotes which sample type the ICV verification is associated with and the order of ICV analysis.
(c) ICV standard was prepared by spiking method blank solutions at stated concentrations.
(d) Concentration found represents average of replicate analyses.

TABLE VII-9. (Continued)

Element	Sample[a,b]	ICV Standard Concentration[c] (μg/L)	Concentration Found[d] (μg/L)	Recovery (%)
Se	BHC-1	10	10.1	101
		20	23.4	116.7
		40	42.2	105
		60	59.7	99.5
	BHC-2	25	30.3	121
		50	58.2	116.4
		75	81.4	108.5
		100	105.8	105.8
		150	151.3	100.9
	FHC-1	25	25.7	102.8
		50	53	106
		75	78.4	104.5
		100	103	103
		125	123.6	98.8
	FHC-2	10	13	130
		25	26.8	107
		50	53	106
		75	77	102.6
		100	100.9	100.9
	FHC-3	10	11.7	117
		25	27.4	109.8
		50	50.4	100.7
Se	SLD	25	24.5	98
		50	50	100
Pb	BHC	10	11.6	116
		25	25.8	103
		50	50.6	101

(a) BHC = Method 29 back-half composite, FHC = Method 29 front-half composite, SLD = solid sample.
(b) Sample identification denotes which sample type the ICV verification is associated with and the order of ICV analysis.
(c) ICV standard was prepared by spiking method blank solutions at stated concentrations.
(d) Concentration found represents average of replicate analyses.

TABLE VII-9. (Continued)

Element	Sample[a,b]	ICV Standard Concentration[c] (μg/L)	Concentration Found[d] (μg/L)	Recovery (%)
Pb	FHC-1	10	10.5	105
		25	27.2	108.8
		50	51.3	102.5
		75	77.5	103.3
		100	99.6	99.6
	FHC-2	10	11.5	115
		25	26.1	104
		50	51.8	103.6
		75	75.2	100.3
	SLD-1	25	26.2	104.8
		50	51.8	103.5
		80	79.6	99.5
		100	100.9	100.9
	SLD-2	25	26.3	105
		50	53.8	107.6
		80	79.4	99.3
Sb	BHC	10	11.7	117
		20	22	110
		40	40.5	101
		60	61	101.6
	SLD	10	9.25	92.5
		25	24.3	97.2
		50	49.8	99.6

(a) BHC = Method 29 back-half composite, FHC = Method 29 front-half composite, SLD = solid sample.
(b) Sample identification denotes which sample type the ICV verification is associated with and the order of ICV analysis.
(c) ICV standard was prepared by spiking method blank solutions at stated concentrations.
(d) Concentration found represents average of replicate analyses.

TABLE VII-10. CALIBRATION RESULTS FOR MERCURY CV-AAS ANALYSIS

Calibration Standard Nominal Concentration (μg/aliq)	Concentration Found (μg/aliq)	Percent Recovery
Method 29 Front Half		
0.05	0.0587	117
0.025	0.0195	78
0.075	0.073	97
0.025	0.0221	88
0.075	0.076	101
Method 29 Back Half		
0.05	0.0486	97
0.05	0.0486	97
0.075	0.0707	94
0.025	0.0237	95
Method 29 $KMNO_4$ Impingers		
0.050	0.0504	101
0.075	0.0718	96
0.025	0.0229	92
0.025	0.0233	93
Solid Process Samples		
0.05	0.0486	97
0.025	0.0229	92
0.075	0.0786	105

Recoveries for ICP-AES analysis of Zn, Pb, Cd, Mn, As, and Be on SRM 2676d and 2677a (as shown in Tables VII-11 and VII-12) were within the QAPP limits for all instances where the concentration was high enough to be detected by the instrument.

Recoveries from the ICP-AES analysis of SRM 1643c (Table VII-13) were acceptable except for cobalt. The results from the regression curve for cobalt show an error in the calculated concentration for the 0.02 ppm and 0.05 ppm standards of -31 percent/27 percent (for duplicate analyses) and +20 percent, respectively. The certified level of Co in SRM 1643c is approximately equal to the instrument detection limit for Co. The low recovery for Co was evaluated on that basis, and since the recoveries for the other elements were acceptable, analysis of the rest of the samples was resumed.

Recoveries from the ICP-AES analysis of SRM 1633a (Table VII-14) were acceptable except for cadmium and barium. The error in the cadmium recovery is believed to be a result of the low level of cadmium in the matrix and the resulting susceptibility to the interelement interference correction. This error is expected to affect all other Cd results at levels approaching the detection limit for Cd in this particular matrix. Spike recoveries determined separately were, however, acceptable. The error in barium is believed due to an extrapolated point beyond the highest standard used for calibration. This was only noticed during data review. It is anticipated that this error will not significantly affect sample data because actual levels measured in the samples were all below the highest standard used for calibration.

Results from the GF-AAS analysis of SRM 1633a are presented in Table VII-15. Recoveries ranged from 97.9 percent to 103.4 percent for the certified values of As, Pb, and Se. The slightly low value of Sb compared with uncertified value indicated antimony may be precipitated as antimony oxide during the nitric acid digestion without the presence of 10 percent (v/v) concentrated HCl. Further method development in minimization of matrix effect might improve recovery in comparison of the uncertified value.

Difficulty was encountered during CV-AAS analysis of SRM 1633a for mercury. Samples which yielded acceptable recoveries for the other elements yielded recoveries for mercury ranging from 150 to 200 percent. This result was repeated for nine

TABLE VII-11. RESULTS FOR ICP-AES ANALYSIS OF SRM 2676d (FILTER)

Trial		Quantity of Material (μg/filter)			
		Zn	Pb	Cd	Mn
1	Found	11.2	8.1	1.05	2.4
	Certified	10.17	7.44	0.97	2.09
	% Recovered	110	109	108	115
2	Found	53.9	14.1	2.9	10.8
	Certified	49.47	14.82	2.81	9.83
	% Recovered	109	95	104	110
3	Found	108.8	31.9	10.8	21.9
	Certified	99.31	29.77	10.04	19.83
	% Recovered	110	107	108	110

TABLE VII-12. RESULTS FOR ICP-AES ANALYSIS OF SRM 2677a (FILTER)

		As (μg/filter)	Be (μg/filter)
Level I	Found	ND[a]	0.145
	Certified	0.269	0.129
	% Recovered	-	112
Level II	Found	3.19[b]	0.72
	Certified	2.69	0.643
	% Recovered	119	113
Level III	Found	26.5	2.95
	Certified	26.92	2.58
	% Recovered	99	114
Level IV	Found	ND	ND
	Certified	0.101	0.050
	% Recovered	-	-

(a) ND indicates not detected.

(b) Based on single analysis.

Table VII-13. Results for ICP-AES Analysis of SRM 1643c (water)

Sample I.D	Cr	Cd	Ni	Ba	Co	Mn	V	Be
Calibration Blank	-0.0007	-	0.0012	-0.0009	-0.0063	0.0020	-0.0033	0.0024
1643C	0.0185	0.0126	0.0536	0.0534	-0.0131	0.0386	0.0230	0.0297
1643C DUP	0.0150	-	0.0457	0.0480	-0.0044	0.0378	0.0190	0.0284
Certified Level	0.0190	0.0122	0.0606	0.0496	0.0235	0.0351	0.0314	0.0232
Percent Recovery	92	103	80	104	-10*	103	77	115

*Recovery does not meet target objective of 100 +/- 25 percent.

Table VII-14. Results for ICP-AES Analysis of SRM 1633a (fly ash)

Sample	Cr	Cd	Ni	Ba	Co	Mn	V	Be
SRM 1633a	192.1261	2.2007	111.1328	810.8358	34.4171	160.0339	274.2894	12.6771
Certified Level	196	1.0	127	1500	46	190	300	12
Percent Recovery	98	220*	88	54*	75	84	91	106

*Recovery does not meet target objectives of 100 +/- 25 percent.

TABLE VII-15. RESULTS FOR GF-AAS ANALYSIS OF SRM 1633a

Element	Given ($\mu g/g$)	Found ($\mu g/g$	Recovery (%)
As	145	142	97.9
Pb	72.4	72.8	100.5
Se	10.3	10.7	103.4
Sb	7(a)	6	86

(a) Value not certified by NIST - for information only.

replicate preparations of the same SRM. Subsequent digestions of the same SRM with different acids yielded the same high recoveries. Spikes made in the same digestions yielded acceptable recoveries. Efforts to attain a new SRM from NIST were unsuccessful as NIST is no longer offering this SRM, and no other similar material would become available within a useful time frame. It is thought that either the certified value was incorrect, or the sample was otherwise contaminated.

Results from analysis of SRM 1632a conducted by CTE are presented in the data reporting form in Figure VII-1.

Accuracy from Spike Recoveries

For ICP-AES analyses, digested samples were spiked at known concentrations using a multielement standard. Spike levels ranged from 0.5 ppm and 2 ppm. Spikings were performed in both duplicate and single samples. Spiked sample recoveries are provided in Table VII-16 for ICP-AES analysis. The percent recoveries for the spikes were all within acceptable limits.

For GA-AAS analyses, Method 29 back-half composite and front-half composite digested samples and solid digested samples were diluted to the proper concentration to meet the linear range of absorption by the specific element to be determined by graphite furnace atomic absorption (GFAA). The sample test solutions were spiked with 10, 20, 25 or 50 μg/L for the spiked recovery test, as well as for the correction of the chemical interference, such as matrix effect, by standard addition. The spiked levels on the solid samples were converted to the spiked content in the original samples in μg/g (ppm). Repeated measurements for the low concentrations and matrix correction were performed for better accuracy and precision. The recovery values given in Table VII-17 meet the target quality objective of within $\pm$25 percent.

For CV-AAS analysis, digested samples were spiked with a known concentration of mercury and analyzed to evaluate recovery. Results from CV-AAS analysis of spiked samples are presented in Table VII-18. The low mercury recovery for a back half spiked sample is considered an isolated case and, based on other QC data, is expected not to have a significant impact on the data.

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SINCE 1908
Member of the SGS Group (Société Générale de Surveillance)

September 16, 1993

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TEL: (303) 373-47
FAX: (303) 373-47

BATTELLE
505 KING AVE.
COLUMBUS, OH 43201
GERHARD A MEYER Ph.D.

Sample identification by
?

SAMPLE ID: METALS APR2993

Kind of sample reported to us	COAL
Sample taken at	XXXXX
Sample taken by	Battelle
Date sampled	------
Date received	July 6, 1993

Analysis report no. 72-251586
Revised QC Report

PARAMETER	NBS 1633A Reported	NBS 1633A True Value	
Antimony, Sb	103.5	100	*1
Antimony, Sb	22.4	25.7	*2
Antimony, Sb	5.44	7.0	*3
Arsenic, As	106	145 ✓	
Barium, Ba	0.13%	0.15%	
Beryllium, Be	12.1	12 ǂ	
Cadmium, Cd	0.81	1.00	
Chloride, Cl	1.02%	1.129%	*4
Chromium, Cr	186	196	
Lead, Pb	72.0	72.4	
Fluoride, F	49	50	*5
Manganese, Mn	100.8	100	*6
Manganese, Mn	180	179 ǂ	
Mercury, Hg	0.28	0.25	*7
Nickel, Ni	105	127 ✓	
Selenium, Se	94.3	100	*8
Selenium, Se	1.17	1.29 *3	as per phone conv 9/16/93 - [illegible]
Vanadium, V	296	297 ǂ	

ǂ according to non-certified values in NIST 1990-1991 Catalog Special Publication 260

* Certified value not available, alternative standard used.
1 Sb, SPEC QC 19 SPEC INDUSTRIES
2 Sb, ERA 9937 ENVIRONMENTAL [illegible]
3 Sb, NBS 1632b NIST
4 Cl, BCSS-1 BRITISH COLUMBIA
5 Fl, RR901 CTE ROUND ROBIN
6 Mn, SPEC QC 19
7 Hg, SARM 20 SOUTH AFRICA REF. MATERIAL
8 Se, SPEC QC 19

Respectfully submitted,
COMMERCIAL TESTING & ENGINEERING CO.

Figure VII-1. Results from Analysis of SRM 1632a Conducted by CTE

Table VII-16. Spike Results for ICP-AES Analysis

Sample	Cr	Cd	Ni	Ba	Co	Mn	V	Be
R1-L12 (ppm)	0.0198	0.0001	-0.1309	0.1935	0.1472	0.0832	0.1918	-0.0007
2 ppm + R1-L12 (ppm)	2.088	2.054	1.909	2.205	2.148	2.090	2.044	1.994
Percent Recovery	103	103	102	101	100	100	93	100
2 ppm + R1-L12D (ppm)	2.135	2.109	1.976	2.263	2.214	2.146	2.104	2.050
Percent Recovery	106	105	105	103	103	103	96	103
BL-L12 (ppm)	0.0025		0.0047	0.004	-0.0136	0.0356	-0.0168	0.0022
BL-L12 + 0.5 (ppm)	0.5101		0.5116	0.4976	0.4803	0.5279	0.4855	0.4863
BL-L12 + 0.5 ppm (dup)	0.503		0.5045	0.4915	0.4911	0.5175	0.4758	0.4748
Percent Recovery	101		101	98	100	97	99	96
BL-L7 (ppm)	0.0058		0.0015	0.0107	-0.022	0.0313	-0.0138	0.0022
BL-L7 + 0.5 ppm	0.4942		0.4881	0.484	0.4765	0.4967	0.4644	0.4632
BL-L7 + 0.5 ppm (dup)	0.5083		0.5018	0.4985	0.4646	0.5176	0.4811	0.4877
Percent Recovery	99		99	96	99	95	97	95
APR2993ESPA (ppm)	1.318	0.1291	0.6017	2.575	1.452	1.277	1.992	0.0671
APR2993ESPA+2 (ppm)	3.12	1.795	2.275	4.105	3.531	2.9	3.545	1.717
Percent Recovery	90	83	84	77	104	81	78	82
APR2993ESPA+2 ppm (dup)	3.259	1.851	2.359	4.225	3.069	2.996	3.67	1.81
Percent Recovery	97	86	88	82	81	86	84	87

TABLE VII-17. SPIKE RECOVERY FOR GF-AAS ANALYSIS

Element		Sample	Spiked (μg/L or	Found μg/g)	Recovery %
As	BHC	150804	10 μg/L	7.4	74.4
	BHC	150833	20	21.7	108.6
	BHC	156162	20	19.9	99.7
	FHC	R1L12	25 μg/L	28.5	113.8
	FHC	R3L12	25	25.3	101.2
	FHC	R2L5	25	20.9	83.7
	FHC	R2L12	25	26.7	106.8
	SLD	427 ESP Ash	47.4 μg/g	47	99
	SLD	427 Bottom Ash	19.3	18.1	94
	SLD	429 Economizer Ash	21.2	18.3	86
	SLD	429 Economizer Ash	21.2	22.7	107
	SLD	429 Bottom Ash	21	18.2	87
	SLD	430 ESP Ash	49.5	46.6	94
	SLD	430 Economizer Ash	22.3	22	98
	SLD	430 Bottom Ash	19.9	15.6	78
Pb	BHC	15084	10 μg/L	8.2	82
	BHC	150833	25	26.7	107
	FHC	R3L2	25 μg/L	24.8	99
	FHC	R3L10	25	22.3	89
	FHC	R3L12	25	28.9	116
	FHC	R2L7	25	19.6	78
	SLD	427 ESPA	23.7 μg/g	20.9	84
	SLD	430 ESPA	24.8	22	89
	SLD	430 SNRB	2.18	2.13	98
	SLD	430 SNRB	2.18	2.62	120
	SLD	430 BOTM	1.99	2.03	102
Se	BHC	150804	10 μg/L	7.2	72
	BHC	150833	20	16.3	82
	BHC	150833	20	21.7	109
	BHC	150833	25	27.1	109
	BHC	150833	50	51.3	103
	BHC	150790	50	49.4	99
	BHC	150790	50	54.8	110
	BHC	150790	50	50.1	100
	BHC	150790	50	49.3	99
	BHC	150804	50	49	98
	BHC	150804	50	52.9	106
Se	BHC	156162	50	49.1	98
	BHC	156162	50	51.5	103

TABLE VII-17. (Continued)

Element		Sample	Spiked (μg/L or	Found μg/g)	Recovery %
Se	FHC	R1L10	25 μg/L	24.3	97
	FHC	R2L10	25	22.6	90
	FHC	R3L12	25	22.6	90
	FHC	R3L2-2	25	22.3	89
	FHC	R1L12	25	25.6	102
	FHC	R1L12	25	27.4	110
	FHC	R3L7	25	21.3	85
	FHC	R3L7	25	43.1	96
	SLD	427 ESPA	9.5 μg/g	9.3	98
	SLD	430 ESPA	9.9	9.3	94
	SLD	427 SNRB	4.4	4.5	102
	SLD	430 SNRB	8.7	8.4	97
	SLD	427 Lime	4.3	4.6	108
Sb	BHC	150804	10 μg/L	7.9	79
	BHC	150833	20	19.8	99
	BHC	150833	20	17.4	87
	BHC	150833	20	18.9	95
	BHC	150790	10	7.7	77
	BHC	156162	20	17	85
	FHC	R2L5	25 μg/L	22.1	89
	FHC	R2L7	25	23.5	94
	FHC	R2L2	25	25.1	101
	SLD	430 Bottom Ash	2.0 μg/g	1.84	92
	SLD	430 Bottom Ash	4	4.2	104
	SLD	429 ESPA	2.4	2.3	98
	SLD	429 ESPA	4.7	4.7	100
	SLD	430 SNRB	3.2	1.9	87
	SLD	430 SNRB	4.4	4.8	109
	SLD	430 ECON	2.2	2.3	108
	SLD	430 ECON	4.5	4.3	95
	SLD	430 Lime	2.3	2.3	100
	SLD	430 Lime	4.6	4.6	100

TABLE VII-18. SPIKED SAMPLE RECOVERIES FOR CV-AAS MERCURY ANALYSIS

Sample	Concentration (μg/aliquot)	% Recovery
FHC[a]		
BL-L7	0.001	--
BL-L7 + 0.05 μg	0.055	98
R1-L12	<0.001	--
R1-L12 + 0.05 μg	0.048	96
BHC[a]		
R3-L10	0.095	--
R3-L10 + 0.05 μg	0.155	120
R1-L7	0.024	--
R1-L7 + 0.05 μg	0.041	34
R2-L5	<0.001	--
R2-L5 + 0.05 μg	0.046	92
$KMNO_4$ Impingers		
R3-L12	0.027	--
R3-L12 + 0.05 μg	0.073	92
R1-L12	0.016	--
R1-L12 + 0.05 μg	0.061	90
SLD[a]		
APR2993 ESP Ash	0.042	--
APR2993 ESP Ash + 0.05 μg	0.094	104
Digestion Blank	<0.02	--
Digestion Blank + 0.05 μg	0.050	100
APR3093 Bottom Ash	<0.02	--
APR3093 Bottom Ash + 0.05 μg	0.053	106

(a) FHC = Method 29 front half composite
BHC = Method 29 back half composite
SLD = Solid sample.

Precision

Precision was determined by analyzing duplicate samples that were prepared side by side by the same method. Results are summarized in Tables VII-19, VII-20, and VII-21 for ICP-AES, GF-AAS, and CV-AAS, respectively. In all cases where the elements were present at measurable concentrations, relative percent differences between duplicate samples were within acceptable limits. For ICP-AES, duplicate analyses of field blanks reflected higher RPDs since the determination was being made at or near the detection limit of the method. For GF-AAS analyses, the range of RPD results, as expected, fluctuated with the analyte concentration and homogeneity of samples and the detection limit and sensitivity of the GF-AAS system for As, Pb, Se, and Sb.

Completeness

All Method 29 samples and solid process samples planned to be collected and analyzed were received by Battelle. A back half portion from one Method 29 train was lost during sample preparation. The percent completeness achieved is summarized below.

Sample Batch	Expected Number of Samples[a]	Number of Samples Analyzed	Completeness (%)
Method 29 Front Half	15	14	93[b]
Method 29 Back Half	15	15	100
Method 29 $KMNO_4$ Impingers	15	15	100
Solids[c]	18	18	100

(a) Excluding QC samples.
(b) Sample lost during laboratory preparation.
(c) Includes coal samples analyzed by CTE.

Table VII-19. Duplicate Sample Results for ICP-AES Analysis

Method 29 Front Half

Sample	Cr	Cd	Ni	Ba	Co	Mn	V	Be
R1-L5	1.080	0.0520	0.4969	0.6248	0.4742	1.658	1.464	0.0213
DUP R1-L5	1.081	0.0520	0.4934	0.6165	0.3975	1.659	1.464	0.0209
RPD %	0.09	0.00	0.71	1.34	17.60*	0.06	0.00	1.90

Method 29 Back Half

Sample I.D	Cr	Cd	Ni	Ba	Co	Mn	V	Be
BL-L7	0.0058		0.0015	0.0107	-0.0220	0.0313	-0.0138	0.0022
BL-L7 (dup)	0.0063		0.0024	0.0072	-0.0347	0.0295	-0.0170	0.0021
RPD %	8.26		46.15*	39.11*	44.80*	5.92	20.78*	4.65
SRM 1643c		0.0129						
SRM 1643c (dup)		0.0123						
RPD%		4.80						

Solid Process Samples

Sample	Cr	Cd	Ni	Ba	Co	Mn	V	Be
APR3093SNRB	0.3868	0.0250	0.1032	0.0913	0.2720	0.3938	0.6035	0.0080
APR3093SNRB DP	0.3826	0.0275	0.1133	0.0843	0.2677	0.3869	0.5945	0.0081
RPD %	1.09	9.52	9.33	7.97	1.59	1.77	1.50	1.24
APR2993ECON	1.459	0.3771	0.6713	2.541	1.919	1.647	2.001	0.0681
APR2993ECON (dup)	1.410	0.3688	0.6599	2.591	2.093	1.811	2.030	0.0676
RPD %	3.42	2.23	1.71	1.95	8.67	9.49	1.44	0.74

*RPD does not meet target objective of less than 10 percent.

TABLE VII-20. DUPLICATE SAMPLE RESULTS FOR GF-AAS ANALYSIS

Element	Sample	Concentration Initial Analysis (μg/L or μg/g)	Concentration Duplicate Analysis (μg/L or μg/g)	RPD (%)
As	BHC R3-L2	-0.16 μg/L	0.14	3000
	BHC FB-L12	-0.01	-0.16	176
	BHC R2-L12	0.8	1.57	65
	FHC R3-L5	487 μg/L	577	16.9
	FHC R3-L5	494	572	14.6
	FHC FB-L7	8.27	10.22	21.1
	FHC FB-L12	9.24	8.76	5.3
	SLD 430SNRB	90.8 μg/g	108	17.3
	SLD 430ECON	57.5	64.3	11.2
Se	BHC R3-L5	14.7 μg/L	21.3	22.5
	BHC FB-L12	6.4	5.7	12.7
	FHC R2-L12	243.2	245.4	0.9
	FHC R3-L5	154	173.2	11.7
	RHC R3-L2	505.7	514.9	1.8
	SLD 430ESPA	21.2 μg/g	21.7	2.4
	SLD 427ECON	0.22	0.17	25.6
	SLD 429ECON	0.11	0.32	97.7
	SLD 430SNRB	6.27	5.88	6.4
Pb	BHC R3-L10	26 μg/L	24.4	6.1
	BHC FB-L12	1.34	1.6	17.7
	FHC R3-L5	50.3	60.5	18.6
	FHC R1-L5	66.4	76.2	13.7
	SLD 430SNRB	5.36 μg/g	5.21	2.8
Sb	BHC FB-L12	-0.29 μg/L	-0.23	23.1
	FHC R3-L5	14.56	17.37	17.6
	SLD427LIME	-0.1 μg/g	0.18	7.0
	SLD427SNRB	0.41	0.55	29.2

TABLE VII-21. DUPLICATE SAMPLE RESULTS FOR CV-AAS ANALYSIS

Sample		Concentration (μg/aliq)	RPD (%)
Front Half			
BL-L7		0.001	-
BK-L7	Duplicate	0.001	0.0
R2-L5		0.013	-
R2-L5	Duplicate	0.013	0.0
R1-L12		<0.001	-
R1-L12	Duplicate	<0.001	0.0
Back Half			
R2-L5		0.0175	-
R2-L5	Duplicate	0.016	8.9
R3-L10		0.038	-
R3-L10	Duplicate	0.038	0.0
R1-L7		0.025	-
R1-L7	Duplicate	0.024	4.1
KMNO4 Impingers			
R3-L12		0.02	-
R3-L12	Duplicate	0.026	26.1
R1-L12		0.005	-
R1-L12	Duplicate	0.007	33.3
Solids			
APR2993ESP Ash		0.043	-
APR2993ESP Ash		0.041	4.8
Digestion Blank		<0.02	-
Digestion Blank	Duplicate	<0.02	0.0
APR3093 Bottom Ash		<0.02	-
APR3093 Botton Ash	Duplicate	<0.02	0.0

Method Detection Limit

The method detection limit for each element analyzed by ICP-AES was calculated by using three times the standard deviation of replicate results from blank or spiked samples. As shown in Table VII-22, the results for the front-half composite of the Method 29 samples were considerably higher than the target value. This is due to a combination of the extremely large impinger volume and the large amount of acid required to digest the particulate.

The method detection limits for GF-AAS analysis of As, Pb, Se, and Sb in Method 29 back-half and front-half samples and solid samples are listed in Table VII-23. The detection limits are calculated from three times of the standard deviation of the element concentration in the actual samples, instead of the standard deviation from element concentration near twice the detection limit. The sample homogeneity, matrix and acidity aspects, and instrumental conditions will also affect the detection limit and deviate from the target detection limit based on ideal case in the pure water matrix.

2. Chloride/Fluoride

QAPP and Method Deviations

Chloride/fluoride analyses were conducted according to the QAPP and Method 26A for the gas samples and Method 300 for the solid samples. Deviations from the QAPP and these standard methods include the following:

TABLE VII-22. METHOD DETECTION LIMIT FOR ICP-AES ANALYSIS

Analyte	Actual Detection Limit for 2 dscm volume** (ug/dscm) FHC*	BHC*	Target Detection Limit for 1.64 dscm volume (ug/dscm)
Cr	50	1.4	2.74
Cd	60	0.9	1.37
Ni	70	1.9	5.49
Ba	60	0.2	0.55
Co	70	1.3	2.74
Mn	60	0.3	0.27
V	65	1.3	2.74
Be	60	0.04	1.37

*FHC = Method 29 front half composite (solid); BHC = Method 29 back half composite (vapor).

**Calculated using 3 times the standard deviation of replicate analysis of blank or low-level spiked sample, 1000 mL impinger volume, 2 dscm gas sample volume, and 0.2 preconcentration factor (for BHC).

TABLE VII-23. METHOD DETECTION LIMIT FOR GF-AAS ANALYSIS

	Actual Detection Limit					Target Detection Limit	
	BHC(a)		FHC(b)		SLD(c)		
Element	(μg/L)	(μg/dscm)(e)	(μg/L)	(μg/dscm)(f)	(μg/g)	(μg/L)	(μg/dscm)
As	0.5	0.25	3(d)	0.75	0.9	1	0.27
Pb	0.3	0.15	4(d)	1	0.2	1	0.27
Se	1.5	0.75	5(d)	1.25	0.4	2	0.55
Sb	0.7	0.35	4(d)	1	0.3	5	1.37

(a) Method 29 back-half composite.
(b) Method 29 front-half composite.
(c) Solid samples.
(d) Based on three times the standard deviation of analyte concentrations in the FHC samples, which had higher concentrations than the solutions used to determine actual detection limit.
(e) Assumes impinger volume of 1000 mL and gas sample volume of 2 dscm.
(f) Assumes impinger volume of 500 mL and gas sample volume of 2 dscm.

Method 26A

(1) The analysis of EPA Performance Evaluation Samples (WPO29) was used (in accordance with Section 9.2.6 of the QAPP) instead of EPA "Audit Samples" referenced in Section 7.7.1 of Method 26A. There is no effect on results because of this deviation from Method 26A. The acceptable range for either reference sample must be analytically achieved to assure method accuracy. The target values for the WPO29 samples were achieved with each calibrated sample run (see Table VII-25, presented later).

(2) Calibration standards were prepared in deionized water instead of 0.1N H_2SO_4 as cited in Section 5.2 of Method 26A. As the majority of the analyses required dilution in deionized water to conform to the analytical range of the detector, deionized water was the appropriate solvent for the calibration standards. There should be no adverse effect on results from this alteration.

Method 300

(1) The instrument calibration was verified approximately each hour of operation with the analysis of an Instrument Calibration Verifier (ICV) standard which has a tolerance of 20 percent from the known value as specified in Section 6.2.6 of the QAPP. Section 9.4 of Method 300 states that the tolerance should be 10 percent. Although 10 percent is achievable precision (see relative percent difference results for duplicates), ICVs require 20 percent because they are analyzed around the clock where temperature changes contribute to a small amount of instrumental drift above 10 percent.

QAPP

(1) Section 5.3.2 of the QAPP (Custody During Lab Analysis) states that samples will be documented in a bound laboratory record notebook. The ion chromatography lab uses a sample log for all incoming samples from which a unique 4-digit number is assigned. Copies of sample chain-of-custody forms maintained in the laboratory served as a record of the personnel and the times involved in sample-handling transactions.

(2) Section 6.2.6 of the QAPP states that a CCV standard will be used in chloride/fluoride analyses for continuing calibration verification. The correct terminology is ICV.

(3) Section 9.2.6 of the QAPP incorrectly refers to the ICV as the CCV.

Calibration Data

Results from the analysis of the ICV standard, which was analyzed approximately once each hour of instrument operation to monitor for instrument drift, are presented in Table VII-24. The acceptable range for this calibration was ± 20 percent or 0.20-0.30 μg/mL. As shown in Table VII-24, this requirement was met for all ICV analyses.

Results from the analysis of a standard reference material, EPA Performance Evaluation WPO29 Minerals #1 and #2, are presented in Table VII-25 along with the SRM acceptable range. As shown, results from multiple analyses of this SRM were all within the acceptable range.

Accuracy

Results from the fluoride/chloride analysis of a spiked sample are presented in Table VII-26. The QAPP data quality objective for accuracy from a spiked sample was 75-125 percent recovery which was met.

Precision

Results for duplicate fluoride/chloride analyses are provided in Table VII-27. Duplicate analyses represent duplicate injections of a sample into the ion chromatograph. The data quality objective for precision for duplicate chloride/fluoride analyses was a relative percent difference of 10 percent which was met for these analyses.

Completeness

A total of 15 Method 26A samples were received for chloride/fluoride analysis as expected. All samples were analyzed and data were reported for all analyses to meet the completeness objective of 100 percent.

TABLE VII-24. ICV RESULTS FOR CHLORIDE/FLUORIDE ANALYSES

Instrument File	ICV Concentration (μg/mL)	Concentration Found (μg/mL)	
		F^-	Cl^-
ZF426	0.25	0.25	0.25
ZF434	0.25	0.25	0.25
ZF441	0.25	0.25	0.24
ZF450	0.25	0.23	0.24
ZF469	0.25	0.26	0.23
ZF473	0.25	0.26	0.22
ZF481	0.25	0.26	0.22
ZF494	0.25	NA[a]	0.24
ZF461	0.25	NA	0.22
ZF487	0.25	NA	0.24
ZE090	0.25	0.25	0.25
ZE098	0.25	0.24	0.26
ZE107	0.25	0.23	0.25
ZE122	0.25	0.23	NA
ZE131	0.25	0.25	0.30
ZE141	0.25	0.24	0.29
ZE149	0.25	0.24	NA
ZE155	0.25	0.25	0.21
ZE167	0.25	0.30	0.22
ZE174	0.25	0.29	0.22
ZE181	0.25	0.29	0.21
ZE189	0.25	0.29	0.22
ZE190	0.25	0.28	0.21
ZE201	0.25	0.27	0.20
ZE206	0.25	0.27	NA
ZE215	0.25	0.27	NA
ZE229	0.25	0.25	0.24
ZE241	0.25	0.25	0.25

(a) NA = Not Applicable.

TABLE VII-25. RESULTS FOR CHLORIDE/FLUORIDE SRM

Instrument File	Acceptable Range ($\mu g/mL$)	Concentration Found ($\mu g/mL$)	
		F^-	Cl^-
ZF448	1.6 - 2.0	1.7	--[(a)]
ZF483	140 - 170	--	160
ZF482	1.6 - 2.0	1.7	--
ZE099	0.38 - 0.54	0.50	--
ZE132	0.38 - 0.54	0.52	--
ZE133	29 - 36	--	29
ZE165	0.38 - 0.54	0.54	--
ZE166	29 - 36	--	29
ZE214	0.38 - 0.54	0.49	--
ZE233	0.38 - 0.54	0.44	--
ZE236	29 - 36	--	33

(a) "--" indicates analyte not determined in analysis.

TABLE VII-26. RESULTS OF CHLORIDE/FLUORIDE SPIKE ANALYSIS

Instrument File	Sample	Concentration Found ($\mu g/mL$)	
		F^-	Cl^-
ZF458	MAY02 Economizer Ash	0.026	0.032
ZF459	MAY02 Economizer Ash + 0.2 ppm Spike	0.220	0.241
	PERCENT RECOVERY	97	105

TABLE VII-27. RESULTS OF DUPLICATE CHLORIDE/FLUORIDE ANALYSES

Instrument File		Sample	Concentration Found ($\mu g/mL$) F^-	Cl^-	Relative Percent Difference, %
ZF457		MAY02 Economizer Ash	0.026	--[a]	
ZF458		MAY02 Economizer Ash	0.025	--	3.9
ZF457		MAY02 Economizer Ash	--	0.033	
ZF458		MAY02 Economizer Ash	--	0.030	9.5
ZE187	R3-L10	155536	89.088	--	
ZE200	R3-L10	155536	86.577	--	2.8
ZE187	R3-L10	155536	--	436.204	
ZE200	R3-L10	155536	--	424.343	2.8

(a) "--" indicates analyte result reported separately in table.

Method Detection Limit

The target analytical method detection limit for chloride/fluoride analyses was 0.014 μg/mL for chloride and 0.003 μg/mL for fluoride. The target emission detection limit was 0.583 μg/dscm for chloride and 0.125 μg/dscm for fluoride based on a 100 mL impinger solution volume and a gas sample volume of 2.4 dscm. The analytical detection limit achieved in these analyses was 0.01 μg/mL for both fluoride and chloride for most samples except for the sulfuric acid reagent blank sample which had a matrix interference that increased the analytical detection limit to 1 μg/mL. The analytical detection limit was calculated according to the QAPP (i.e., multiplying the standard deviation of 8 determinations by Student's t value). The actual emission detection limits achieved for fluoride ranged from 1.5 μg/dscm in the Location 12 field blank to 2.4 μg/dscm in the sample from Run 1 at Location 5. These actual emission detection limits are considerably higher than the target detection limits due to the extremely high impinger solution volume. Significant levels of chloride were detected in all samples; the actual emission detection limit achieved for chloride in the distilled water reagent blank (using an assumed gas sample volume of 2.83 dscm) was 0.75 μg/dscm which was close to the target detection limit of 0.583 μg/dscm.

3. Polycyclic Aromatic Hydrocarbons

QAPP and Method Deviations

EPA Method 8270, which was cited in the QAPP for general guidance in PAH analyses, is applicable to the determination of semivolatile organic compounds in solid waste, soils, and ground water matrices. This method cannot be applied directly to determine PAH in flue gas samples. In this study, PAH analysis was performed by using a capillary GC column/MS technique which is the same technique used in EPA Method 8270. Note that in EPA Method 8270, in addition to PAH, groups of SVOCs are also determined; thus, the MS is operated in the full scan mode. In order to reach the detection limit for target PAH of less than 1 ng/dscm for this study, samples were analyzed by operating the MS in the selected ion monitoring (SIM) mode to achieve better detection limits. The analytical method used to determine PAH was detailed in the QAPP. All the samples were processed and analyzed according to the QAPP except for the following changes which are not expected to influence the analytical results:

(1) In Section 7.3 (on page 7-8) of the QAPP, 40 mL of hexane was to be added to the silica column. The 40 mL was incorrect in the QAPP; 10 mL was actually used.

(2) In Section 7.3 (on page 7-8 of the QAPP), 150 mL of hexane/dichloromethane (DCM) was to be added to the silica column. The 150 mL hexane/DCM was incorrect in the QAPP; 200 mL was actually used.

(3) In Section 7.3 (on page 7-9), extracts were to be concentrated to a final volume of 100 μL prior to analysis. For some samples, the extracts were concentrated to a final volume of 1 to 4 mL due to the high amount of extractable organic material present in the hexane/DCM fraction from the silica column.

(4) In Table 7-3 of the QAPP, target PAH compounds to be determined included acenaphthene (not acenaphthalene) and indeno[1,2,3-c,d]pyrene (not indeno[1,2,3-c,d]perylene).

Calibration Data

The quantification of each target PAH in all the analyses of standard solutions used for routine calibration were within 30 percent of the true value as stated in the QAPP. Table VII-28 summarizes the deviation from the true value from these analyses, and Table VII-29 gives the deviation from the true value of individual standard analyses.

Blank Results

The QC sample results are given in Tables VII-30 and VII-31. As shown in Table VII-30, trace amounts of some target PAH were found in the method blank. Since PAH are common environmental contaminants, trace amounts of these compounds were

TABLE VII-28. SUMMARY OF PERCENT OF DEVIATION FOR STANDARD ANALYSES

Compound	Deviation (%) Maximum	Minimum	Mean
Naphthalene	28.4	1.0	17.5
1-Methylnaphthalene	26.0	5.0	16.9
2-Methylnaphthalene	24.0	3.0	15.2
Biphenyl	27.0	6.0	15.6
Acenaphthylene	22.0	4.0	12.8
Acenaphthene	24.0	5.0	14.8
Fluorene	20.0	2.0	12.8
Phenanthrene	25.0	2.0	13.0
Anthracene	18.0	2.0	9.6
Fluoranthene	27.4	2.0	15.2
Pyrene	30.0	0.0	17.0
Benzo(a)anthracene	25.0	5.0	13.2
Chrysene	22.0	0.0	11.0
Benzofluoranthenes	27.0	2.0	12.3
Benzo(e)pyrene	21.0	0.0	10.8
Benzo(a)pyrene	28.0	1.0	14.9
Indeno(1,2,3-c,d)pyrene	30.0	3.0	15.3
Dibenzo(a,h)anthracene	29.0	3.0	15.9
Benzo(g,h,i)perylene	24.0	1.0	10.8

TABLE VII-29. PERCENT DEVIATION OF STANDARD ANALYSIS RESULT FROM NOMINAL CONCENTRATION OF STANDARD SOLUTION

	Percent Deviation (a)							
Compound	0.5 ng/μL	0.5 ng/μL	0.1 ng/μL	0.1 ng/μL	0.1 ng/μL	0.1 ng/μL	0.1 ng/μL	0.1 ng/μL
Naphthalene	22.6	28.4	25.0	13.0	22.0	17.0	18.0	28.0
1-Methylnaphthalene	16.4	16.4	18.0	12.0	21.0	19.0	23.0	22.0
2-Methylnaphthalene	17.0	17.4	16.0	7.0	22.0	15.0	14.0	23.0
Biphenyl	19.4	14.8	16.0	10.0	18.0	17.0	19.0	21.0
Acenaphthylene	9.8	11.0	19.0	12.0	17.0	14.0	15.0	18.0
Acenaphthene	14.8	16.2	21.0	13.0	16.0	17.0	15.0	18.0
Fluorene	9.6	18.4	9.0	15.0	7.0	19.0	17.0	16.0
Phenanthrene	9.0	8.2	15.0	25.0	2.0	22.0	16.0	12.0
Anthracene	5.2	8.8	7.0	18.0	11.0	15.0	3.0	18.0
Fluoranthene	25.4	27.4	25.0	17.0	10.0	13.0	13.0	6.0
Pyrene	28.8	26.6	28.0	21.0	25.0	15.0	14.0	14.0
Benzo(a)anthracene	9.6	20.6	8.0	9.0	10.0	10.0	12.0	13.0
Chrysene	5.8	17.0	21.0	4.0	5.0	3.0	2.0	10.0
Benzofluoranthenes	16.8	17.6	12.0	8.0	11.0	9.0	10.0	14.0
Benzo(e)pyrene	7.8	12.0	21.0	0.0	12.0	9.0	12.0	3.0
Benzo(a)pyrene	10.6	8.4	3.0	26.0	20.0	11.0	13.0	27.0
Indeno(1,2,3-c,d)pyrene	19.6	6.2	8.0	29.0	20.0	10.0	14.0	25.0
Dibenzo(a,h)anthracene	17.6	14.2	18.0	25.0	29.0	14.0	7.0	3.0
Benzo(g,h,i)perylene	6.6	7.4	12.0	24.0	1.0	8.0	14.0	2.0

(a) Results are from single daily analysis of standard solution at indicated concentration.

TABLE VII-29. (Continued)

Compound	Percent Deviation[a]								
	0.1 ng/μL	0.1 ng/μL	0.1 ng/μL	0.1 ng/μL	0.1 ng/μL	0.1 ng/μL	0.1 ng/μL	0.05 ng/μL	0.05 ng/μL
Naphthalene	21.0	1.0	20.0	2.0	5.0	14.0	7.0	28.0	26.0
1-Methylnaphthalene	10.0	5.0	18.0	10.0	12.0	22.0	20.0	26.0	16.0
2-Methylnaphthalene	8.0	3.0	15.0	4.0	23.0	14.0	20.0	24.0	16.0
Biphenyl	11.0	6.0	10.0	9.0	27.0	14.0	15.0	24.0	12.0
Acenaphthylene	12.0	10.0	5.0	4.0	15.0	11.0	8.0	22.0	14.0
Acenaphthene	5.0	9.0	11.0	9.0	23.0	13.0	13.0	24.0	14.0
Fluorene	11.0	14.0	12.0	.9.0	17.0	20.0	15.0	2.0	6.0
Phenanthrene	17.0	13.0	10.0	8.0	15.0	10.0	12.0	10.0	16.0
Anthracene	11.0	18.0	7.0	12.0	4.0	7.0	13.0	4.0	2.0
Fluoranthene	6.0	25.0	4.0	2.0	10.0	11.0	13.0	26.0	24.0
Pyrene	3.0	21.0	1.0	0.0	9.0	15.0	12.0	30.0	26.0
Benzo(a)anthracene	23.0	25.0	15.0	15.0	5.0	10.0	17.0	10.0	12.0
Chrysene	14.0	19.0	21.0	22.0	4.0	13.0	21.0	6.0	0.0
Benzofluoranthenes	27.0	12.0	10.0	13.0	12.0	12.0	16.0	6.0	2.0
Benzo(e)pyrene	20.0	6.0	8.0	13.0	11.0	7.0	17.0	10.0	14.0
Benzo(a)pyrene	21.0	21.0	11.0	13.0	28.0	1.0	8.0	4.0	26.0
Indeno(1,2,3-c,d)pyrene	7.0	7.0	3.0	12.0	29.0	30.0	14.0	6.0	20.0
Dibenzo(a,h)anthracene	25.0	15.0	13.0	6.0	26.0	26.0	13.0	6.0	12.0
Benzo(g,h,i)perylene	22.0	5.0	2.0	9.0	17.0	24.0	3.0	8.0	18.0

(a) Results are from single daily analysis of standard solution at indicated concentration.

TABLE VII-30. TOTAL AMOUNT OF PAH FOUND IN LABORATORY QC SAMPLES

Compound	Method Blank (ng)	Matrix Spike (ng)
Naphthalene	15.0	277.0
1-Methylnaphthalene	20.0	26.0
2-Methylnaphthalene	8.0	9.0
Biphenyl	9.0	11.0
Acenaphthylene	ND(a)	ND
Acenaphthene	7.0	15.0
Fluorene	11.0	17.0
Phenanthrene	27.0	47.0
Anthracene	2.0	3.0
Fluoranthene	10.0	18.0
Pyrene	6.0	13.0
Benzo(a)anthracene	1.0	2.0
Chrysene	2.0	4.0
Benzofluoranthenes	4.0	5.0
Benzo(e)pyrene	1.0	1.0
Benzo(a)pyrene	ND	2.0
Indeno(1,2,3-c,d)pyrene	ND	2.0
Dibenzo(a,h)anthracene	ND	4.0
Benzo(g,h,i)perylene	ND	1.0

(a) ND = Not detected.

TABLE VII-31. PAH CONCENTRATION IN LABORATORY QC SAMPLES(a)

Compound	Method Blank (ng/dscm)	Matrix Spike (ng/dscm)
Naphthalene	5.00	92.33
1-Methylnaphthalene	6.67	8.67
2-Methylnaphthalene	2.67	3.00
Biphenyl	3.00	3.67
Acenaphthylene	ND(b)	ND
Acenaphthene	2.33	5.00
Fluorene	3.67	5.67
Phenanthrene	9.00	15.67
Anthracene	0.67	1.00
Fluoranthene	3.33	6.00
Pyrene	2.00	4.33
Benzo(a)anthracene	0.33	0.67
Chrysene	0.67	1.33
Benzofluoranthenes	1.33	1.67
Benzo(e)pyrene	0.33	0.33
Benzo(a)pyrene	ND	0.67
Indeno(1,2,3-c,d)pyrene	ND	0.67
Dibenzo(a,h)anthracene	ND	1.33
Benzo(g,h,i)perylene	ND	0.33

(a) Gas sample volume of 3 dscm was used to calculate concentrations.
(b) ND = Not detected.

expected from laboratory handling. Note that a higher level of naphthalene was found in the matrix spike sample as compared to the method blank. A clean XAD-2 trap was used to prepare the matrix spike but not the method blank. The matrix spike was spiked with dioxins/furans prior to extraction as a spiked QC sample for dioxin/furan analyses, but was not spiked with PAH and therefore represents essentially a second laboratory method blank for PAH analyses. The higher background level of naphthalene in the matrix spike is mainly due to the clean XAD-2 trap's absorbing some naphthalene (most abundant PAH in air) from ambient air while the sample was being processed. All the PAH concentrations reported for field samples were not corrected for background levels found in these QC samples.

Accuracy and Precision

Accuracy, precision, and completeness were calculated by the procedures described in the QAPP. Tables VII-32 and VII-33 summarize the accuracy, precision, and completeness of the QC samples and the combined QC and field samples, respectively. The individual recovery data of QC and field samples are given in Tables VII-34 and VII-35.

Satisfactory recoveries of both the field-spike and lab-spike compounds were obtained from all the QC samples. These results suggested that a minimum loss of PAH had occurred during sample handling and sample preparation.

Completeness

A total of 19 QC and field samples were collected. All 19 samples were extracted and GC/MS analysis was conducted on 18 out of these 19 samples yielding a completeness of 95 percent. The hexane/DCM fraction from sample R3-L2 could not be analyzed because the extract was saturated with white precipitate at the final volume of 4 mL. Note that low recoveries of laboratory-spike compounds were found in sample R2-L5. This is mainly from the sample handling process in the Soxhlet extraction step. The laboratory spiking solution was spiked onto the XAD-2 resin. Then the filter and loose particles associated with the filter were added to the same Soxhlet extractor. The Soxhlet

TABLE VII-32. ACCURACY, PRECISION, AND COMPLETENESS FOR QC SAMPLES

Spike Compound(a)	Accuracy (%)	Precision (%)	Completeness (%)
D12-Chrysene	94	5.7	100
D12-Benzo(k)fluoranthene	78	4.5	100
D12-Benzo(e)pyrene	77	4.6	100

(a) D12-Chrysene is the field-spike compound, D12-benzo(k)fluoranthene and D12-Benzo(e)pyrene ae the laboratory spike compounds.

TABLE VII-33. ACCURACY, PRECISION, AND COMPLETENESS FOR ALL SAMPLES

Spike Compound(a)	Accuracy(a) (%)	Precision(b) (%)	Completeness(c) (%)
D12-Benzo(k)fluoranthene	55 (66)	37 (12)	95
D12-Benzo(e)pyrene	55 (62)	36 (15)	95

(a) The first number is the average recovery of all samples and the second number in the parentheses is the average recovery of samples excluding R1-L10, R2-L10, R2-L5, and R3-L10.

(b) The first number is the relative standard deviation of spike recoveries of all samples. The second number in parentheses is the relative standard deviation of spike recoveries of sample excluding R1-L10, R2-L10, R2-L5, and R3-L10.

(c) Sample R3L2 was not analyzed by GC/MS because of extremely high extractable organic mass.

Table VII-34. Percent Recovery Data for QC Samples (%)

Spike Compound	Method Blank	Matrix Spike	Field Blank L7	Field Blank L12	Average	Std.Dev.	Percent Std.Dev.
d12-Chrysene	--(a)	94	87	100	94	5.3	5.7
d12-Benzo[k]fluoranthene	74	81	--	--	78	3.5	4.5
d12-Benzo[e]pyrene	73	80	--	--	77	3.5	4.6

(a) "--" indicates not spiked into sample.

TABLE VII-35. PERCENT RECOVERY DATA FOR FIELD SAMPLES (%)

Compound	R1L2	R2L2	R1L5	R2L5	R3L5	R1L7	R2L7	R3L7	R1L10	R2L10	R3L10	R1L12	R2L12	R3L12	All Samples			Excluding R2-L5, R1-L10 R2-10, and R3-10		
															Averag	Std.Dev	Percent Std.Dev	Averag	Std.Dev	Percent Std.Dev
D12-Benzo[k]fluoranthene	53	59	62	11*	60	65	66	66	37*	18*	24*	64	80	63	52	20	39	64	6.6	10
D12-Benzo[e]pyrene	61	55	50	17*	58	60	65	55	36*	19*	24*	64	74	50	49	18	36	59	7.0	12

*Recovery does not meet target objective of 50 - 120 percent.

extractor was not big enough to retain all the sample. The sample was then redivided into two Soxhlet extractors. This handling process can cause the loss of the spiked compounds. Low recoveries of the laboratory spike compounds were also obtained from all three samples collected at Location 10. These low recoveries are probably due to the sample matrix effect of large amounts of particles in these samples.

Method Detection Limit

The limit of detection of target PAH was calculated as described in Section 11.3.3 of the QAPP. The results are summarized in Table VII-36.

4. Dioxins/Furans

QAPP and Method Deviations

For dioxin/furan analysis, the following revisions to Method 23 were made:

- Soxhlets were pre-extracted and samples extracted with methylene chloride rather than toluene as specified in Method 23. Methylene chloride was the preferred extraction solvent for obtaining volatile PAH analytes. As stated in the QAPP, both dioxin/furan and PAH data were obtained by extracting one sample and splitting the extract into two portions, one for dioxin/furan specific cleanup and one for PAH specific cleanup. To ensure recovery of the volatile PAHs while not affecting the efficiency of extracting dioxins/furans, methylene chloride was used as the extraction solvent.

- Samples were Soxhlet extracted for 18 hours rather than 16 as specified in Method 23 and the QAPP. The additional extraction time should not have influenced analytical results adversely.

TABLE VII- 36. LIMIT OF DETECTION FOR PAH

	Achieved Analytical Detection Limit (pg/μL)	Total Amount Detectable in 1 mL Extract (pg)	Achieved Emission Detection Limit (ng/dscm(a))	Target Detection Limit (ng/dscm)
Naphthalene	0.006	6.4	0.002	0.15
1-Methylnaphthalene	0.007	6.8	0.002	0.15
2-Methylnaphthalene	0.005	5.5	0.002	0.15
Biphenyl	0.005	4.9	0.002	0.15
Acenaphthylene	0.005	4.9	0.002	0.15
Acenaphthene	0.008	7.5	0.003	0.15
Fluorene	0.009	8.8	0.003	0.15
Phenanthrene	0.006	5.6	0.002	0.15
Anthracene	0.003	3.3	0.001	0.15
Fluoranthene	0.007	7.0	0.002	0.15
Pyrene	0.006	6.3	0.002	0.15
Benzo(a)anthracene	0.013	13.2	0.004	0.15
Chrysene	0.012	11.9	0.004	0.15
Benzofluoranthenes	0.011	11.0	0.004	0.29
Benzo(e)pyrene	0.011	10.9	0.004	0.29
Benzo(a)pyrene	0.016	16.2	0.005	0.29
Indeo(1,2,3-c,d)pyrene	0.021	20.7	0.007	0.29
Dibenzo(a,h)anthracene	0.023	22.9	0.008	0.29
Benzo(g,h,i)perylene	0.019	18.7	0.006	0.29

(a) Based on assumed sample volume of 3 dscm.

- The container 2 acetone/methylene chloride wash was filtered through a quartz fiber filter into a Kuderna-Danish apparatus and concentrated to 15-20 mL in a 65-75°C water bath. The filter from this filtration was Soxhlet extracted with the Method 23 XAD-2 filter and resin. The extract and concentrated wash were combined with other extracts from the Method 23 train and analyzed as one solution. Method 23 describes concentrating the container 2 wash to 1-5 mL on a rotovap at $<37°C$ and adding this concentrate to the Soxhlet before extracting. The difference between the two methods should not have affected analytical results.

- The container 3 toluene rinse was not prepared and analyzed separately as the toluene QA rinse specified in Method 23. Instead, all components from the Method 23 train were combined and analyzed as one solution as specified in the QAPP.

- The container 4 impinger solution, which is not analyzed according to Method 23, was neutralized with 0.1N NaOH then extracted three times with 60 mL of methylene chloride. This extract was concentrated and combined with other components from the Method 23 train for analysis as specified in the QAPP.

- The calibration and spiking solutions used were at concentrations recommended by EPA Method 1613. Method 1613 solution concentrations vary slightly from Method 23 and also include additional $^{13}C_{12}$-labeled internal standards. The additional labeled internal standards provide better accuracy in identifying and quantifying analytes.

- Several Method 23 samples had large amount of particulate collected on the filter. It was realized after beginning extraction on several of these samples that extraction was impeded when the filter, XAD, and particulate matter were combined in a single Soxhlet extractor. To correct for this, excess particulate associated with the filters from samples R2-L5, R3-L5, and R3-L10 was placed into a second Soxhlet apparatus for extraction separate from the XAD-2 resin and filter. These extra Soxhlets were not spiked with the labeled internal standards, but were combined after extraction with the Soxhlet containing the XAD-2 resin and filter which was spiked. Low recoveries of internal standards on the samples with high particulate loading which were not split into two Soxhlet apparatus (R1-L5, R1-L10, and R2-L10) indicate that the extraction efficiency was compromised. Splitting the sample into two Soxhlet apparatus appears to have helped the extraction efficiency as noted by better internal standard recovery. Unfortunately, Sample R2-L5 was split into two

Soxhlet extractors after spiking and the excess sample handling after spiking appears to have negated the improvement in recoveries achieved with using two Soxhlet extractors for extraction.

- Extract cleanup involved two additional steps which are recommended cleanup procedures in EPA Method 1613. First, the addition of 2,3,7,8-TCDD-$^{37}Cl_4$ as a recovery standard to each extract prior to any cleanup was used to evaluate the recovery of analytes through the cleanup procedures. The cleanup recovery standard provides an additional measure of quality control. Second, the addition of acid/base washing of the extract prior to column cleanups. The acid/base wash is a routine step in both EPA Methods 8290 and 1613.

- Cleanup columns included acid/base silica, alumina, and AX21/celite as required in Method 23; however, amounts of column packing material and elution solvents were similar to those listed in EPA Method 1613 and varied slightly from Method 23 in some instances.

- The GC oven temperature program for separating the analytes on the DB5 column follows Method 1613, which varies somewhat from Method 23, but provides adequate separation of all analytes of interest.

- As specified in the QAPP, no second column confirmation of 2,3,7,8-TCDF on a DB225 column was performed. The DB5 column does not separate 2,3,7,8-TCDF from other TCDF isomers. As a result, values obtained for 2,3,7,8-TCDF could include contributions from coeluting, non-2,3,7,8 isomers.

- Some surrogate standards listed in Method 23 were added to the field blank sampling trains before sample collection to evaluate sampling train collection efficiency. However, surrogate standards were not spiked onto the XAD-2 resin used to collect actual emission samples so losses due to sampling and shipping could not be evaluated for emission samples.

Calibration Data

For the initial calibration, the mean relative response factors were within the quality control limits of 25 percent for native dioxins/furans and 30 percent for $^{13}C_{12}$-labelled dioxin/furan internal standards as shown in Table VII-37. The routine continuing calibration response factors were within the limit of $\pm$ 30 percent from the mean relative response

TABLE VII-37. RESULTS FROM DIOXIN/FURAN INITIAL AND CONTINUING CALIBRATION

Analyte	Initial Calibration										Continuing Calibration		
Native Response Factors													
	CS1	CS2	CS3	CS4	CS5	AVG	SD	RSD	+30%	-30%	CS3	CS3	CS3
2378 TCDD	1.102	1.006	1.234	1.083	1.093	1.104	0.074	6.679	1.435	0.772	1.005	1.033	1.028
12378 PeCDD	1.172	1.091	1.247	1.073	1.180	1.153	0.063	5.489	1.498	0.807	1.025	1.033	0.998
123478 HXCDD	1.187	1.247	1.128	1.142	1.242	1.189	0.049	4.149	1.546	0.832	1.066	1.025	0.950
123678 HXCDD	1.247	1.180	1.101	1.219	1.242	1.198	0.054	4.505	1.557	0.838	1.030	0.880	0.925
123789 HXCDD	1.206	1.313	1.221	1.240	1.265	1.249	0.038	3.009	1.624	0.874	1.139	1.068	1.052
1234678 HPCD	1.107	1.008	1.118	1.074	1.171	1.095	0.054	4.918	1.424	0.767	1.047	0.961	0.978
OCDD	1.306	1.266	1.271	1.227	0.928	1.200	0.138	11.491	1.559	0.840	1.167	1.114	1.106
2378 TCDF	1.061	1.064	1.060	0.991	1.054	1.046	0.028	2.646	1.360	0.732	0.911	0.923	0.946
12378 PeCDF	1.006	1.008	0.976	0.969	1.015	0.995	0.019	1.885	1.293	0.696	0.881	0.946	0.889
23478 PeCDF	0.981	1.027	0.944	1.006	1.057	1.003	0.039	3.848	1.304	0.702	0.821	0.915	0.845
123478 HXCDF	1.241	1.217	1.254	1.184	1.144	1.208	0.040	3.303	1.570	0.846	1.136	1.174	1.135
123678 HXCDF	1.319	1.274	1.256	1.284	1.191	1.264	0.042	3.330	1.644	0.885	1.181	1.178	1.170
123789 HXCDF	1.334	1.202	1.205	1.185	1.128	1.211	0.068	5.578	1.574	0.847	1.108	1.139	1.116
234678 HXCDF	1.249	1.196	1.248	1.218	1.211	1.224	0.021	1.710	1.592	0.857	1.175	1.182	1.139
1234678 HPCDF	1.625	1.557	1.330	1.555	1.475	1.508	0.101	6.701	1.961	1.056	1.198	1.177	1.176
1234789 HPCDF	1.398	1.356	1.339	1.329	1.291	1.343	0.035	2.607	1.745	0.940	1.218	1.367	1.270
OCDD	1.559	1.509	1.546	1.457	0.985	1.412	0.216	15.304	1.835	0.988	1.184	1.384	1.230
Recovery Response Factors													
2378-TCDD-13C12	1.079	1.047	1.041	1.063	1.098	1.066	0.021	1.972	1.385	0.746	1.006	1.046	1.059
12378-PeCDD-13C12	0.805	0.714	0.717	0.683	0.744	0.733	0.041	5.619	0.952	0.513	0.722	0.701	0.763
123478-HXCDD-13C12	0.880	0.744	0.848	0.855	0.873	0.840	0.049	5.890	1.092	0.588	0.872	0.816	0.832
123678-HXCDD-13C12	0.925	0.840	0.936	0.886	0.932	0.904	0.037	4.052	1.175	0.633	0.941	0.950	0.911
1234678-HPCDD-13C12	0.866	0.921	0.977	0.996	0.857	0.924	0.056	6.077	1.201	0.646	0.957	0.826	0.857
OCDD-13C12	0.860	0.868	1.000	0.946	1.008	0.936	0.063	6.697	1.217	0.655	0.853	*0.624	0.704
2378-TCDF-13C12	1.807	1.831	1.995	1.831	1.738	1.840	0.084	4.586	2.392	1.288	1.382	1.546	1.451
12378-PeCDF-13C12	1.494	1.315	1.388	1.349	1.431	1.396	0.063	4.504	1.814	0.977	1.020	1.039	1.124
23478-PeCDF-13C12	1.631	1.315	1.468	1.273	1.438	1.425	0.126	8.860	1.853	0.998	1.036	1.045	1.149
123478-HXCDF-13C12	1.420	1.388	1.488	1.411	1.545	1.450	0.058	3.997	1.886	1.015	1.236	1.092	1.090
123678-HXCDF-13C12	1.503	1.426	1.583	1.434	1.525	1.494	0.059	3.929	1.943	1.046	1.250	1.149	1.120
123789-HXCDF-13C12	1.461	1.341	1.409	1.484	1.508	1.441	0.060	4.143	1.873	1.008	1.242	1.100	1.053
234678-HXCDF-13C12	1.155	1.171	1.212	1.246	1.260	1.209	0.041	3.375	1.571	0.846	1.073	0.987	0.968
1234678-HPCDF-13C12	0.953	0.932	1.122	1.029	1.082	1.024	0.073	7.119	1.331	0.717	0.980	0.867	0.804
1234789-HPCDF-13C12	0.929	0.900	1.015	1.015	1.024	0.977	0.051	5.259	1.269	0.684	0.927	0.701	0.721
2378-TCDD-37Cl4	1.094	1.092	1.092	1.092	1.124	1.099	0.013	1.152	1.428	0.769	0.986	1.010	1.013

* = Outside ± 30 percent limit.

factor for all analytes except OCDD-$^{13}C_{12}$ which was slightly below -30 percent on the second day of analysis. Because this one response factor was only slightly outside acceptable limits, the initial calibration was not repeated. The OCDD-$^{13}C_{12}$ response factor returned within the QC limits on the next analysis day.

Quality Control Sample Results

Two field blanks and a laboratory method blank were prepared and analyzed with the actual samples to demonstrate that field sampling and laboratory analysis procedures did not contaminate the actual samples. Very low levels of OCDD were found in all three blank samples (less than 70 pg/dscm). No other analytes were found in the method blank and the field blank from location 12; however, the field blank from location 7 also contained low levels of TCDF, HxCDF, and OCDF (less than 7 pg/dscm of each). These results indicate that the sampling and analytical activities do not compromise the integrity of the samples.

A matrix spike sample was prepared by spiking clean XAD-2 resin with native 2,3,7,8-substituted dioxin/furan standards and processing this spiked resin through the same extraction and cleanup processes as the actual samples. As shown in Table VII-38, recoveries ranged from 71 percent for 1,2,3,7,8,9-HxCDD to 104 percent for OCDF and were well within the acceptable limits of 40 to 120 percent.

Accuracy

Recoveries of $^{13}C_{12}$-labeled dioxin/furan internal standards, which were spiked into all actual and quality control samples to demonstrate the efficiency of extracting dioxins/furans from the sample matrix are shown in Table VII-39. All samples were spiked with the labeled internal standards immediately before extraction except for the field blanks which were spiked with the internal standards in the field. The acceptable range for internal standard recovery was 40 to 120 percent. The only samples for which the recoveries are low for all internal standards are R1-L5, R1-L10, R2-L5, and R2-L10 from the SNRB™ and ESP inlets. As mentioned earlier, the large amounts of particulate collected on filters at these

TABLE VII-38. RESULTS FOR DIOXIN/FURAN MATRIX SPIKE SAMPLE

ANALYTE	CONC. FOUND (pg/dscm)	SPIKE LEVEL (pg/dscm)	PERCENT RECOVERY	ION RATIO	LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO
2378-TCDD	187	200	93	0.75	2378-TCDD-13C12	2000	1450	72	0.79
12378-PeCDD	920	1000	92	1.58	12378-PeCDD-13C12	2000	1636	82	1.58
123478-HxCDD	821	1000	82	1.24	123478-HxCDD-13C12	2000	1585	79	1.22
123678-HxCDD	780	1000	78	1.27	123678-HxCDD-13C12	2000	1655	83	1.20
123789-HxCDD	711	1000	71	1.23	1234678-HpCDD-13C12	2000	1143	57	0.98
1234678-HpCDD	862	1000	86	1.06	OCDD-13C12	4000	1437	36*	0.89
OCDD	1878	2000	94	0.90					
2378-TCDF	186	200	93	0.76	2378-TCDF-13C12	2000	1360	68	0.79
12378-PeCDF	945	1000	95	1.37	12378-PeCDF-13C12	2000	1194	60	1.55
23478-PeCDF	881	1000	88	1.42	23478-PeCDF-13C12	2000	1400	70	1.57
123478-HxCDF	895	1000	89	1.24	123478-HxCDF-13C12	2000	1186	59	0.52
123678-HxCDF	892	1000	89	1.23	123678-HxCDF-13C12	2000	1229	61	0.52
123789-HxCDF	893	1000	89	1.22	123789-HxCDF-13C12	2000	1199	60	0.52
234678-HxCDF	926	1000	93	1.27	234678-HxCDF-13C12	2000	898	45	0.53
1234678-HpCDF	850	1000	85	1.03	1234678-HpCDF-13C12	2000	1048	52	0.45
1234789-HpCDF	971	1000	97	0.99	1234789-HpCDF-13C12	2000	955	48	0.44
OCDF	2082	2000	104	0.90					
					CLEANUP STANDARD				
					2378-TCDD-37Cl4	800	743	93	

*Outside 40-120% limit.

TABLE VII-39. DIOXIN/FURAN INTERNAL STANDARD RECOVERIES AND ASSOCIATED PRECISION FOR ALL SAMPLES (%)

LABELED COMPOUNDS	Method Blank	Field Blank L12	Field Blank L7	R1-L7	R1-L5**	R2-L7	R1-L10**	R1-L12	R2-L5**	R2-L10**	R2-L12	R3-L5	R3-L12	R3-L7	R3-L10	Matrix Spike	AVG	SD	RSD	
2378-TCDD-13C12	90	88	83	83	1.04	111	5.16	93	3.96	10	96	91	94	96	89	72	69	39	56	*
12378-PeCDD-13C12	82	30**	85	79	0.95	128	7.91	87	2.67	11	87	88	96	101	90	82	66	41	62	*
123478-HxCDD-13C12	76	13**	81	79	0.66	109	5.99	79	1.94	8	91	83	86	89	82	79	60	39	64	*
123678-HxCDD-13C12	83	19**	81	85	3.70	116	11.18	93	5.07	12	101	89	94	99	82	83	66	40	61	*
1234678-HpCDD-13C12	65	58	71	69	2.45	104	7.64	75	3.83	9	82	78	76	82	70	57	57	32	57	*
OCDD-13C12	34**	58	60	58	0.33	81	2.37	58	1.11	4	65	65	68	72	56	36**	45	28	63	*
2378-TCDF-13C12	73	68	66	66	0.86	89	7.67	63	3.32	15	77	74	75	78	72	68	56	30	54	*
12378-PeCDF-13C12	44	8**	63	58	0.49	73	3.86	49	1.93	4	67	65	73	82	69	60	45	30	67	*
23478-PeCDF-13C12	64	30**	66	60	0.83	97	7.73	66	2.81	12	66	68	74	83	70	70	52	31	59	*
123478-HxCDF-13C12	3**	0.2**	17**	13**	0.10	6**	0.18	7**	0.31	0	69	65	67	70	62	59	27	31	112	*
123678-HxCDF-13C12	6**	0.2**	29**	22**	0.18	11**	0.38	12**	0.54	0	69	69	68	73	62	61	30	31	101	*
123789-HxCDF-13C12	65	60	62	62	0.64	90	7.49	65	2.05	11	59	70	68	73	62	60	51	28	55	*
234678-HxCDF-13C12	59	65	66	64	0.33	88	5.13	69	1.40	7	72	70	74	77	64	45	52	30	58	*
1234678-HpCDF-13C12	38**	0.4**	61	55	0.42	61	2.91	52	1.73	3	69	67	67	70	61	52	41	29	69	*
1234789-HpCDF-13C12	56	18**	57	53	0.29	85	4.59	62	1.43	6	65	60	65	65	58	48	44	28	63	*
CLEANUP STANDARD																				
2378-TCDD-37Cl4	99	100	99	99	95	90	98	96	95	95	100	100	99	101	93	93	97	3	3	

*RSD outside of <40% limit.
**Sample recoveries outside of 40-120% limit (for sample or individual isomer as noted).

(QPro Filename: VII-39)

locations appears to have impeded extraction efficiency. As soon as this was discovered, the samples with excess particulate were extracted in two Soxhlet apparatus instead of one, with the extracts then combined for further processing. Extraction in two Soxhlet systems appears to have corrected the problem as seen by the improved internal standard recoveries for R3-L5 and R3-L10. In addition, each sample extract was spiked with 2,3,7,8-TCDD-$^{37}Cl_4$ prior to cleanup to demonstrate recovery efficiency through acid/base washing and the three cleanup columns. Recovery of this cleanup standard ranged from 90 to 101 percent indicating that recovery of the analytes through the cleanup procedures is quite good.

Precision

Method precision for dioxin/furan analysis was determined by calculating the relative standard deviation of the recoveries of labeled internal standards added to the samples before extraction. As shown in Table VII-39, when all actual and QC samples are taken into account, the relative standard deviation (RSD) is outside the 40 percent limit for all but the cleanup standard 2,3,7,8-TCDD-$^{37}Cl_4$ because of the very low recoveries obtained on samples with high particulate loading which were not extracted in two Soxhlets. If the RSD is determined from all samples except those where the particulate loading impeded extraction efficiency (as shown in Table VII-40), then all recoveries are within 40 percent RSD except for 1,2,3,4,7,8-HxCDF-$^{13}C_{12}$ and 1,2,3,6,7,8-HxCDF-$^{13}C_{12}$ which had RSDs of 84 and 72 percent, respectively.

Completeness

The data for dioxin/furan analysis is 100 percent complete. No samples were lost during field sampling, sample preparation or analysis.

Method Detection Limits

Detection limits were calculated for any analyte not detected and are provided in the dioxin/furan data forms presented in Appendix B of this report. In most cases, actual

TABLE VII-40. DIOXIN/FURAN INTERNAL STANDARD RECOVERIES AND ASSOCIATED PRECISION WITHOUT SAMPLES R1-L5, R1-L10, R2-L5, AND R2-L10 (%)

LABELED COMPOUNDS	Method Blank	Field Blank L12	Field Blank L7	R1-L7	R1-L12	R3-L7	R2-L7	R2-L12	R3-L5	R3-L12	R3-L10	Matrix Spike	AVG	SD	RSD
2378-TCDD-13C12	90	88	83	83	93	96	111	96	91	94	89	72	91	9	10
12378-PeCDD-13C12	82	30	85	79	87	101	128	87	88	96	90	82	86	22	25
123478-HxCDD-13C12	76	13	81	79	79	89	109	91	83	86	82	79	79	22	28
123678-HxCDD-13C12	83	19	81	85	93	99	116	101	89	94	82	83	85	23	27
1234678-HpCDD-13C12	65	58	71	69	75	82	104	82	78	76	70	57	74	12	17
OCDD-13C12	34	58	60	58	58	72	81	65	65	68	56	36	59	13	23
2378-TCDF-13C12	73	68	66	66	63	78	89	77	74	75	72	68	73	7	10
12378-PeCDF-13C12	44	8	63	58	49	82	73	67	65	73	69	60	59	19	32
23478-PeCDF-13C12	64	30	66	60	66	83	97	66	68	74	70	70	68	15	23
123478-HxCDF-13C12	3	0	17	13	7	70	6	69	65	67	62	59	36	31	84 *
123678-HxCDF-13C12	6	0	29	22	12	73	11	69	69	68	62	61	40	29	72 *
123789-HxCDF-13C12	65	60	62	62	65	73	90	59	70	68	62	60	66	8	13
234678-HxCDF-13C12	59	65	66	64	69	77	88	72	70	74	64	45	68	10	15
1234678-HpCDF-13C12	38	0	61	55	52	70	61	69	67	67	61	52	55	19	35
1234789-HpCDF-13C12	56	18	57	53	62	65	85	65	60	65	58	48	58	16	27
CLEANUP STANDARD 2378-TCDD-37Cl4	99	100	99	99	96	101	90	100	100	99	93	93	97	4	4

* = RSD outside <40% limit.

(QPro Filename: VII-40)

detection limits were significantly below the target detection limits listed in the QAPP. For example, the target detection limit for 2,3,7,8-TCDD was 0.06 ng/dscm and actual detection limits of 0.0027 ng/dscm (2.7 pg/dscm) and 0.0051 ng/dscm (5.1 pg/dscm) were achieved for Field Blank-L12 and R3-L5 samples, respectively.

5. Carbonyls

QAPP and Methods Deviations

For the analysis of carbonyls in Method 0011 impinger samples, changes from the QAPP are the following:

(1) Figure 4-38 in the QAPP shows that a filter was in-line ahead of the impingers. However, no filters were used for this sampling system. Upon return of samples to Battelle, a significant amount of particulate material was observed in the impinger solutions. To perform the analyses, the impinger solutions were filtered using Millex-SR 0.5 μm single-use filter units (Millipore Corporation) to obtain particulate free solution for HPLC analysis.

(2) Acetonitrile was to be used for rinsing the probes and glassware, since it was also used as the DNPH solution. However, methylene chloride was used in the field. These two solvents do not mix and the partitioning ratio for carbonyl derivatives is unknown. The acetonitrile layer in impingers 1 and 2 solutions was analyzed for all samples. For one sample both the methylene chloride and acetonitrile layers were analyzed to determine which solvent the DNPH derivatives preferred. In addition, unexpectedly large volumes of methylene chloride were used for rinsing which further complicated the analysis.

(3) EPA Method 0011 procedures were used for collection of carbonyls but with the following exception. In the QAPP, DNPH in acetonitrile (0.25 g/L) was specified for use (and was used) rather than the DNPH in acidified water (3.75 g/L) which is specified in EPA Method 0011. DNPH/acetonitrile solution is used in Method TO-11.

Accuracy

A laboratory spike was not prepared along with the samples for this study to evaluate analytical accuracy. Results from a routine laboratory spike experiment conducted after sample analyses are presented in Table VII-41. For this experiment, a stock solution of six underivatized aldehydes in water was prepared and a 2-mL aliquot was added to 2 mL of a TO-11 DNPH/acetonitrile working solution (0.25 g/L). The calculated spike level of each aldehyde and the amount recovered is shown in the first and second column of Table VII-41. A ten-fold and a hundred-fold dilution of the stock aldehyde solution were also prepared and reacted with the DNPH/acetonitrile working solution. The calculated concentrations and percent recovered at these levels are also indicated in Table VII-41. The working standard that is routinely injected into the HPLC instrument every analysis day (i.e. control standard) is at the 2 μg/mL level. The three spikes cover that level as well as an order of magnitude above and below it. Recovery values obtained in this laboratory spike experiment met the target quality objective for carbonyl recovery of 80-120 percent for all but a low level formaldehyde spike.

Precision

Analyses of the samples showed no carbonyls present, therefore triplicate analyses were not carried out. However, triplicate analyses were completed for the carbonyl standards ranging in concentrations from 0.01 to 2.0 ng/μL. Table VII-42 shows the analytical precision from these standard analyses.

Completeness

A total of eight Method 0011 samples were received from April 26 and May 2 test days (excluding field reagent and blanks). Run 2 samples were not collected from Locations 2 and 5 and Run 3 samples were not collected from all locations. Although the first and second impinger solutions were analyzed individually, they are counted as one sample.

TABLE VII-41. CARBONYL RECOVERIES FOR LABORATORY SPIKE SAMPLES

Compound	Spike Level (μg/mL)	Percent Recovered	Spike Level (μg/mL)	Percent Recovered	Spike Level (μg/mL)	Percent Recovered
Formaldehyde	0.28	122	2.8	120	28	114
Acetaldehyde	0.2	90	2	89	20	85
Propionaldehyde	0.247	94	2.47	95	24.7	89
Crotonaldehyde	0.226	92	2.26	99	22.6	97
Butyraldehyde	0.21	89	2.1	91	21	89
Benzaldehyde	0.211	133	2.11	111	21.1	110

TABLE VII-42. PRECISION DETERMINED FROM TRIPLICATE ANALYSES OF CARBONYL STANDARDS

Analyte	Relative Standard Deviation of Triplicate Analyses (%)					
	0.01 ng/uL Standard	0.05 ng/uL Standard	0.1 ng/uL Standard	0.4 ng/uL Standard	1.0 ng/uL Standard	2.0 ng/uL Standard
Formaldehyde	19.9 *	1.3	1.1	1.4	0.4	0.4
Acetaldehyde	11.1 *	7.1	3.4	1.1	1.9	1.7
Acrolein	3.3	8.4	4.3	0.8	0.1	0.6
Acetone	15.5 *	4.7	1.6	0.4	0.5	0.2
Propionaldehyde	13.6 *	2.8	0.4	1.0	0.2	0.1
Crotonaldehyde	24.2 *	7.3	6.1	0.8	3.4	0.4
Butyraldehyde	20.7 *	6.4	7.0	3.1	0.5	0.0
Benzaldehyde	60.1 *	5.3	4.1	0.9	0.3	0.6

*RSD does not meet target quality objective of less than 10%.

	Number of Samples Collected	Number of Data Points per Sample	Total Number of Data Points
Amount of Data Obtained:	8	8	64
Amount of Data Expected:	15	8	120
Completeness:			53%

Method Detection Limit

The stated detection level for the carbonyls was 1.4 μg/dscm. Carbonyl species were not detected in any of the emission samples at or above this level. Subsequent to the analyses, a signal response was chosen that approximated the instrument noise level which, along with solvent volume as well as the sampled volume, was used to derive an estimated detection limit value for a particular sample. These values were less than the 1.4 μg/dscm target. It is these values that are reported in the carbonyl table.

6. Volatile Organic Compounds

QAPP and Method Deviations

For analysis of volatile organic compounds (VOC) in gas emission samples collected with Method 18 Tedlar bags, changes from the QAPP

(1) QC information was obtained for all 41 TO-14 compounds. However, the first seven compounds on the target list in the QAPP were not quantified in the emission samples because of contamination from SO_2 which was also collected in the bags.

(2) A glass beads trap (-150°C) and six port valves were used to preconcentrate sampled air instead of the two-phase adsorbent trap and Dynatherm preconcentrator system. The use of this trap resulted in no effect on the identification and quantitation of the TO-14 compounds. The change was made because of higher background levels of benzene obtained when using the Dynatherm system.

(3) Sample volume for preconcentration was limited to 25 cc instead of the planned 300 cc because of the excessive amount of SO_2 in the bag samples.

Accuracy

The analytical results of the QC samples associated with the VOC analyses are shown in Table VII-43. The calibration run was a 10 to 1 dynamic dilution of a 41 component calibration cylinder that was analyzed on the same day as the Tedlar bag QC samples. The field spike sample was obtained by filling a bag initially with a 10 to 1 dilution of the calibration mixture and then sending it to the field. Half of the field spike bag was drawn through the field sampling system into a second Tedlar bag to obtain a process sample. The trip blank was a bag filled initially with ultra-zero air that was sent along with the field spike bag. The ratio of spike/cal indicates that most of the target compounds remain unchanged during short term storage in the field spike sample (i.e. ± 25 percent). Most recoveries for the field spike sample meet the accuracy objective of 80-120 percent. The less volatile compounds do not store as well. The ratio of the process/spike indicates a drop off in recovery for the compounds eluting after tetrachloroethene (i.e. the less volatile compounds). The low recoveries in the process sample could be due to the procedures used in the field to generate the sample or to losses during shipping and handling. The trip blank bag shows extremely high dichloromethane values. Dichloromethane was used as a solvent rinse in the field and it is suspected that this use was the source of contamination.

Precision

Table VII-44 shows the relative standard deviation of the three calibration runs as well as the relative percent difference (RPD) from duplicate analyses of the spike and field process bags. Note that the spike level was 30 ppb of the 41 component standard and not 10 ppb as originally indicated in the QAPP. The RPD for the duplicate analyses of the spike and field process bag samples is below the 10 percent data quality objective for most of the more volatile compounds. Precision for compounds eluting after tetrachloroethene (again, the less volatile compounds) is not as good as evidenced by RPDs generally higher than 10 percent.

TABLE VII-43. RESULTS FOR VOC QUALITY CONTROL SAMPLES (ppb)

Analyte	Calibration Cylinder 5/1/93	Field Spike #155871	Process Sample #155873	Trip Blank #155872	Recovery Spike/Cal (%)*	Recovery Proc/Spike (%)*
trichlorofluoromethane (Freon-11)	33.1	29.9	28.9	0.0	90	97
1,1-dichloroethene	28.0	24.9	21.6	0.0	89	86
dichloromethane	43.6	37.4	33.0	197.8	86	88
3-chloropropene	32.9	34.7	24.3	2.0	106	70 **
1,1,2-trichloro-1,2,2-trifluoroethane	25.7	22.5	20.1	0.0	88	89
1,1-dichloroethane	31.9	29.7	25.7	0.4	93	86
cis-1,2-dichloroethene	32.5	31.0	29.5	0.0	95	95
trichloromethane	31.7	29.3	26.5	0.0	93	90
1,2-dichloroethane	31.0	28.4	24.8	0.0	92	87
1,1,1-trichloroethane	22.8	19.8	18.7	0.2	87	94
benzene	26.4	22.0	18.1	3.1	83	83
carbon tetrachloride	26.0	24.9	21.5	0.0	96	86
1,2-dichloropropane	25.7	22.3	19.1	0.0	87	85
trichloroethene	22.6	21.2	17.1	0.0	94	81
cis-1,3-dichloropropene	29.8	25.4	15.2	1.2	85	60 **
trans-1,3-dichloropropene	31.0	25.5	14.7	0.0	82	58 **
1,1,2-trichloroethane	26.2	21.1	14.4	0.0	80	68 **
toluene	22.7	17.5	13.6	3.9	77 **	77 **
1,2-dibromoethane	32.2	27.8	17.6	0.0	86	63 **
tetrachloroethene	22.9	19.7	14.0	0.0	86	71 **
chlorobenzene	24.8	24.4	9.1	0.0	98	37 **
ethylbenzene	21.5	16.9	6.2	1.5	78 **	37 **
m+p-xylene	19.7	16.7	8.9	1.7	85	53 **
styrene	22.4	15.5	4.8	0.0	69 **	31 **
1,1,2,2-tetrachloroethane	22.9	17.3	5.8	0.0	75 **	34 **
o-xylene	22.1	16.4	6.7	0.0	74 **	41 **
4-ethyl toluene	18.3	21.8	4.3	0.0	119	20 **
1,3,5-trimethylbenzene	18.7	22.4	6.6	0.0	119	29 **
1,2,4-trimethylbenzene	18.2	15.1	2.5	14.7	83	16 **
benzyl chloride	29.5	12.2	1.5	0.0	41 **	13 **
m-dichlorobenzene	19.3	11.7	2.4	4.6	61 **	21 **
p-dichlorobenzene	27.3	24.8	3.4	5.9	91	14 **
o-dichlorobenzene	21.8	14.8	2.2	0.0	68 **	15 **
1,2,4-trichlorobenzene	16.7	5.8	0.0	9.0	35 **	0 **
hexachlorobutadiene	14.5	5.7	0.5	0.0	39 **	8 **

*Data quality objective is 80 - 120% recovery.
**Recovery outside target objective.

TABLE VII-44. PRECISION RESULTS FOR VOC REPLICATE ANALYSES

Analyte	Average of Triplicate Calibration Cylinder Analyses (ppb)	Relative Standard Deviation (%)	Average of Duplicate Field Spike Analyses (ppb)	Relative Percent Difference (%)*	Average of Duplicate Process Sample Analyses (ppb)	Relative Percent Difference (%)*
trichlorofluoromethane (Freon-11)	34.7	4.0	31.8	12.2 **	29.2	2.6
1,1-dichloroethene	31.0	8.6	26.2	9.5	23.4	15.6 **
dichloromethane	51.5	15.0	41.2	18.4 **	36.8	20.2 **
3-chloropropene	43.9	22.0	36.7	10.6 **	30.4	40.3 **
1,1,2-trichloro-1,2,2-trifluoroethane	26.8	3.6	23.2	5.5	20.7	6.4
1,1-dichloroethane	35.3	8.6	31.7	12.2 **	26.6	6.4
cis-1,2-dichloroethene	42.3	20.1	38.9	40.7 **	32.8	19.8 **
trichloromethane	34.2	6.4	31.5	13.9 **	28.0	10.3
1,2-dichloroethane	33.4	6.7	28.8	2.9	25.5	5.6
1,1,1-trichloroethane	23.1	3.3	20.1	2.8	19.4	7.0
benzene	28.2	5.8	23.5	12.9 **	19.8	17.3 **
carbon tetrachloride	27.1	4.6	26.5	11.6 **	22.9	12.5 **
1,2-dichloropropane	26.6	5.9	23.5	10.3	18.6	5.1
trichloroethene	24.5	6.9	21.5	3.3	15.6	19.0 **
cis-1,3-dichloropropene	26.5	12.5	23.3	18.4 **	14.8	5.4
trans-1,3-dichloropropene	34.5	9.1	23.4	18.0 **	13.5	18.5 **
1,1,2-trichloroethane	27.8	8.6	20.2	9.3	14.0	5.5
toluene	23.9	4.5	17.9	4.1	13.4	3.3
1,2-dibromoethane	36.7	10.5	26.6	9.1	16.9	8.6
tetrachloroethene	24.7	8.7	19.9	1.6	13.2	12.2 **
chlorobenzene	31.3	18.2	24.6	1.2	12.0	48.3 **
ethylbenzene	26.1	15.4	22.4	49.4 **	9.7	70.7 **
m+p-xylene	25.4	22.1	19.5	28.7 **	8.6	8.6
styrene	100.3	70.7	14.7	10.7 **	5.0	6.6
1,1,2,2-tetrachloroethane	25.8	10.2	16.5	9.7	6.0	6.1
o-xylene	29.6	23.3	16.6	2.7	6.8	3.6
4-ethyl toluene	20.6	10.6	17.5	50.1 **	4.7	14.4 **
1,3,5-trimethylbenzene	21.1	10.6	21.1	12.0 **	5.0	64.6 **
1,2,4-trimethylbenzene	17.8	18.7	13.4	26.2 **	2.3	14.5 **
benzyl chloride	38.2	19.8	16.4	51.2 **	2.1	54.3 **
m-dichlorobenzene	25.8	23.0	18.0	70.1 **	2.9	31.1 **
p-dichlorobenzene	36.5	22.8	29.3	31.1 **	4.0	32.6 **
o-dichlorobenzene	29.6	23.0	12.8	31.1 **	1.8	51.1 **
1,2,4-trichlorobenzene	24.7	28.2	5.9	4.3	1.5	200.0 **
hexachlorobutadiene	16.6	11.3	5.5	8.4	0.2	200.0 **

*Data quality objective for relative percent difference is less than 10%.
**Precision outside target objective.

Completeness

A total of 12 Tedlar bags were received from the April 30 (9 bags) and May 1 (3 bags) test days. This count excludes the trip blank, field spike and process Tedlar bag QC samples. In addition, one bag was received from the April 27 test day and four bags from the April 29 test day, but these five samples were not analyzed because the received bags were deflated (a strong smell of SO_2 was present). Only 35 of the 41 target VOC components could be quantified because of SO_2 contamination in the bags. Completeness achieved is summarized below:

	Number of Samples	Number of Data Points Per Sample	Total Number of Data Points
Amount of Data Expected	15	41	615
Amount of Data Obtained:	12	35	420
Completeness			68%

Method Detection Limit

Because of the decrease in sample volume used for preconcentration, the actual detection level achieved for these analyses is 0.5 ppb. The target detection limit was 0.1 ppb for a 300 cc sample size. Attempts were made to increase the preconcentrated amount to 50 cc. However, at this volume and above, the mass spectrometer source pressure exceeded the allowable limit and the mass spectrometer unit shut down.

VIII. REFERENCES

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2. N. Bloom, Frontier Geosciences, personal communication to J. Czuczwa, Babcock & Wilcox Co., September 2, 1993.

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APPENDIX A

SPECIATED MERCURY MEASUREMENTS

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January 26, 1994
Eric M. Prestbo and Nicolas S Bloom

Discovery of Methyl Mercury Artifact in the Solid Sorbent Speciation (S ^{3}) method for Coal Combustion Fluegas

We have stated in both reports and presentations (Prestbo and Bloom, 1993, Bloom et al., 1993) that monomethyl mercury (MMHg) can be measured and is found in coal combustion flue gas in the range of 5-15% of the total Hg. Because of very recent experiments we have completed in the laboratory, we now know that the MMHg we were measuring and reporting is due to an artifact. Only through painstaking laboratory work were we able to discover the unusual chemical reactions which produce MMHg in solution. We discovered that Hg(II) and S(IV) collected on the KCl/soda lime sorbent, when digested in 10% acetic acid solution will form MMHg on the high pH surface of the dissolving soda lime. The likely mechanism leading to this can be found (in retrospect) in a paper by Lee and Rochelle (1987). This finding was quite surprising considering that SO_2 is known to be a reducing and not an oxidizing compound. The MMHg forms due to the release of methyl groups during the degradation of acetic acid in conjunction with the oxidation of $SO_3^{=}$.

What we can state convincingly is that all previous flue gas data generated by our laboratory overestimates the amount of MMHg. The MMHg fraction should tentatively be considered as part of the Hg(II) fraction of the total Hg in fluegas until our ongoing investigations are completed. It should also be clearly stated that although the MMHg values are no longer valid, this is not true for Hg(II), Hg^0 and especially total Hg. Further, please refrain from stating that MMHg is *not* present in fluegas until we have a chance to complete some field site studies using a refined methodology.

We are actively pursuing the problem encountered. Initially we will investigate non-methyl containing solutions (i.e. citric acid) for dissolving KCl/soda lime to avoid the artifact. Secondly, we will use several other means of collecting flue gas, including unique impinger solutions to more conclusively determine the presence or absence of MMHg in combustion flue gas.

As you know, speciation of trace metals, and especially mercury is difficult in any matrix. We regret that previous MMHg fluegas data was in error. We will continue to communicate to you any of our new findings as we have with this one.

Please don 't hesitate to call us if you have any questions or need further clarification on this issue.

References

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Prestbo E.M. and Bloom N.S. (1993) "Recent advances in the measurement of mercury species in combustion flue gas using solid phase adsorption and cold vapor atomic fluorescence spectroscopy (CVAFS)", Presented at the AWMA 86th Annual Meeting, June 13-18, (93-TA-32.05).

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Jean Czuczwa
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May 17, 1993

Dear Dr. Czuczwa,

Enclosed please find tables containing the mercury speciation data for the fluegas at the Burger Station (SNRB Pilot). The table contains both raw amounts of Hg, ng/sample trap, as well as blank corrected fluegas concentrations ($\mu g/m^3$ at 68^oF, dry). There are some very odd, but consistent patterns in the data which I cannot comment on without further information. Being able to interpret these peculiarities would be of great help not only to your work, but to the further refinement of this analytical method, and hypotheses-forming about fluegas Hg reactions. Thus, I would appreciate your help in obtaining any of the following information as soon as possible (preferably before I go to Sweden, May 19, but at least before the EPRI air toxics meeting, July 12): Coal type, chloride, and sulfur content; Fluegas chloride content at both sampling locations; temperatures and chemicals added in the SNRB pilot reactor; anything else that seems pertinent to the following peculiarities:

(1) Extremely high oxidized Hg trapping efficiencies (<98%) for the ESP side, but very high breakthrough (in fact, greater Hg on the backup traps!) for the SNRB side.

(2) On the 29th, considerably more Hg in the SNRB than the ESP--the increase being due to more oxidized Hg than the day before or after.

(3) High between-day variability in the [Hg_{total}].

Analytically, the data look quite good, so I am looking to the actual chemistry of the system to explain these odd results. **Please note that at this time, due to the very high and unexplained breakthrough of oxidized species at the SNRB location, the fraction of Hg(II) and MMHg bust be taken as a bare minimum.** Further investigation would certainly indicate that these fractions must be higher (Much higher?) and the Hg^o correspondingly lower. One hypotheses might be that in the fluegas, they are in the chloride form, which strongly adsorbs on the soda-lime traps, while after the SNRB, they are in the hydroxide form, which does not.

Also, included with this data are invoices for both the analytical and field work, which have also been sent to accounts payable. We would appreciate having the payment expedited, as our company will face a serious cash flow problem this summer as we refurbish our new laboratory space. Thank you for your help. Please call me if you have questions concerning the data or its interpretation. I hope to be able to work with you again on future projects.

Best wishes,

Nicolas bloom

Analytical and Sampling Method for Mercury Speciation in Flue Gases

(extracted from EPRI annual report, RP-3177-18, February, 1993)

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Experimental Methods

Sampling. The speciation sampling train (Bloom, 1993) consisted of a series of 2 pairs of tandem solid sorbant traps, through which fluegas was pulled at a rate of approximately 0.5 L/min under 5-10" Hg vacuum. The first pair of traps were 0.25" diameter teflon tubes containing 10 cm of 10-20 mesh KCl impregnated soda lime granules. The trapping material was prepared by dissolving 100 grams of KCl in 400 mL of water, and mixing with 1000 g of soda-lime granules. The mixture was then oven-dried at 110°C, ground and sieved between 10 and 20 mesh, and ashed at 600°C for 6 hours. Approximately 2 grams (10 cm) of the material was packed into the teflon tubes between plugs of silanized glass wool. The second pair of traps were commercially available iodated carbon traps (MSA, Pittsburgh), designed for the collection of mercury vapours (Braun and Metzger, 1987; Mofitt and Kupel, 1974).

The traps are situated in a sampling train such that the fluegas passed through a quartz tube to the soda-lime traps, then through the iodated carbon traps (figure 1). The sampling train and quartz tube are maintained at 100-120°C during sampling to avoid condensation of water vapour. Samples are collected non-isokinetically from a single point well away from the walls of the flue. In many cases, as a QA measure, a parallel sampling train, consisting only of iodated carbon traps is collected. This train gives total gaseous mercury, which may then be compared directly with the sum of species obtained on the parallel system.

Samples are generally collected without filters, so that the Hg on particulates adds to the results of the soda-lime traps (oxidized Hg). However, particulate Hg is usually measured on the ESP samples, and given the low Hg levels, combined with the poor efficiency of particulate collection with low-flow non-isokinetic sampling, the error introduced in this way is between 0-5% of the total values observed. In cases where both gas phase and particulate Hg is required, the gaseous train described above is fitted with a quartz wool plug filter to separate out virtually all particulate. A filter from a separate isokinetic sampling train is then analysed to obtain particulate Hg data, which may be added to the gas phase results generated as above.

Dry gas volume is measured, after passage through a desiccant (Drierite™) with an integrating thermal mass flowmeter, calibrated for air. Since actual fluegas contains approximately 10% CO_2, a correction (approximately -0.2% in volume per 1% CO_2) is made to the measured sample volumes to take into account the difference in heat capacity of the gases. Concentrations are generally reported as dry fluegas at 70°F. During the course of the one extensive study, the mass flowmeters were compared at several flowrates (0.1-0.7 L/min) with a bubble flowmeter, and the results found to be accurate to within better than 1%.

Generally samples are collected for two hours at an initial flowrate of 0.5 L/min. Over this time period, the flow rate usually drops to approximately 0.4 L/min, as the soda lime material expands, due to the absorption of CO_2. This results in sample volumes of generally 0.05 m^3, which are accurately determined by the integrating flowmeters. In some cases, sample times up to 4 hours (0.1 m^3) have been employed, to facilitate direct intercomparison with other techniques, or at very low mercury sites (oil fired facilities, after advanced pollution control equipment). In these cases, sample flowrate diminishes dramatically (to approximately 0.2 L/min), by the end of the sampling period.

After collection, the sample traps and quartz probe liners are plugged with teflon plugs, and stored in a low mercury environment until analysis. Although no storage tests have been conducted, the speciation information on the soda-lime traps appears stable at least a period of several weeks. The mercury concentrations collected on the iodated carbon traps is stable indefinitely when plugged with teflon plugs.

Coal and ash samples were collected directly into EPA-style trace metal cleaned sample vials. Typically, the samples were already in powdered form, and so were simply aliquoted prior to analysis. In some cases, coal or bottom ash was collected in chunks, and was thus pulverized in an alumina ball mill prior to analysis.

Analysis. Quantification of Hg is made using cold vapour atomic fluorescence spectrometry (CVAFS), following appropriate sample pre-treatment (Bloom and Fitzgerald, 1987). All standards are ultimately traceable to the lab stock standard for total Hg supplied by the National Bureau of Standards (NBS-3133, lot #290702). Methylmercury standards, prepared in the lab, are cross-compared to this NBS primary standard. Also, where possible, certified standard materials were analysed along with the samples.

Total (and elemental) Hg on iodated carbon traps is determined by $SnCl_2$ reduction of small aliquots (100-500 uL) of acid digests, purging and preconcentration on gold (Bloom and Crecelius, 1983; Moffitt and Kupel, 1974), and CVAFS detection. The samples are digested at 70°C for 2-3 hours in 18.2 or 25.6 mL teflon vials with 5 mL of a mixture of 7:3 HNO_3/H_2SO_4, and diluted to volume with 0.02 N BrCl. Soda lime traps can be analysed for total oxidized Hg, after dissolution with 0.02 N BrCl in similar teflon vials.

To obtain chemical speciation information, soda-lime traps are first dissolved in 10 mL of acetic acid diluted with water to 125 mL in teflon bottles. Ionic and methyl Hg are determined by aqueous phase ethylation, purging onto carbotrap, cryogenic GC separation, and CVAFS detection (Bloom, 1989). Methyl mercury is determined as methylethyl mercury, while ionic mercury is determined as diethyl mercury. Ionic mercury may also be determined on the same samples by $SnCl_2$ reduction, collection gold, and CVAFS detection. From the acetic acid digestates, methylmercury is not released, thus allowing only the Hg(II) to be determined.

Total Hg and speciation on ash samples is determined similarly to that above, after modified digestion procedures. The ash samples are digested with hot refluxing aqua regia, and then diluted to 100 mL with low Hg water, prior to analysis. NBS certified flyash is also determined in this manner, as a QA check. Methyl mercury is determined using aqueous phase ethylation, on separate ash aliquots, after leaching with 25% KOH in methanol (Bloom, 1989).

A new method for the determination of total Hg in coal was developed during this project. Aliquots of coal (0.2 grams) are placed in a 110 mL teflon bomb with 5 mL perchloric acid, 7 mL nitric acid, and 3 mL sulfuric acid. The bomb is microwave digested until a clear yellow solution results (3-5 minutes on medium-low, 900 watt oven). The solution is then diluted to 100 mL with 0.02 N BrCl, and analysed by CVAFS as for other total Hg samples. NBS certified coal, as well as digestion spike recoveries were analysed to verify the method.

As a further check on the determination of Hg in the solid substrates, a selection of the ash and coal samples were also determined by chemical separation/NAA by the nuclear chemistry group at the "J Stefan" Institute, Ljubljana, Slovenia. This completely independent comparison also provides an indirect check on the overall analytical methods and standards.

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Burger Station (for B&W)
Gas Phase Hg Speciation (April 27-30, 1993)

run	side	vol. m^3	traps	uncorrected mercury (ng/trap)				
				total	ionic	methyl	Hg^o	probe
#315	ESP out	0.1174	315		838.9 638.3 605.9	199.9 186.0 181.1	32.2 33.4 35.1	
4/27/93			backups		8.7	1.6	2.0	
13:17-17:19		blank corr total ng/spl			683.0	189.2	32.1	
			μg/m^3	7.70	5.82	1.61	0.27	
#317	SNRB out	0.1260	317		125.4	22.3	535.2	
4/27/93			backups		254.4	20.5	1.4	
10:56-15:23		blank corr total ng/spl			388.8	41.4	533.5	
			μg/m^3	7.65	3.09	0.33	4.23	
#123	ESP out	0.1173	123		516.9 572.0	97.3 111.6	55.7	
4/29/93			backups		<5	4.9	1.6	
13:14-18:28		blank corr total ng/spl			534.4	108.0	54.2	
			μg/m^3	5.94	4.56	0.92	0.46	
#124	SNRB out	0.1353	124		289.6	75.3	391.3	
4/29/93			backups		487.0	74.9	1.5	
12:51-17:31		blank corr total ng/spl			756.6	148.8	389.7	
			μg/m^3	9.57	5.59	1.10	2.88	

B&W/Burger April 29, 1993 (p.2 of 4)

run	side	vol. m^3	traps	uncorrected mercury (ng/trap)				
				total	ionic	methyl	Hg^o	*probe*
#125	SNRB out	0.1030	125		227.3	43.9	376.6	
4/29/93			backups		280.9	40.5	1.4	
17:45-20:45		blank corr total ng/spl			488.2	82.9	375.1	
			$\mu g/m^3$	**9.18**	**4.74**	**0.80**	**3.64**	
#126	ESP out	0.0900	126		407.7	67.0 73.8 72.5	13.8 18.1	
4/29/93			backups		16.8	2.0	1.4	
19:25-21:25		blank corr total ng/spl			404.5	71.7	14.5	
			$\mu g/m^3$	**5.45**	**4.49**	**0.80**	**0.16**	
#127	SNRB out	0.1146	127		138.8	22.6	381.2 362.9 400.9	
4/30/93			backups		175.6	30.4	1.0	
9:30-14:11		blank corr total ng/spl			294.4	51.6	380.2	
			$\mu g/m^3$	**6.34**	**2.57**	**0.45**	**3.32**	
#128	ESP out	0.1161	128		596.3	163.0	42.9	
4/30/93			backups		9.7	5.3	1.3	
9:39-14:06		blank corr total ng/spl			586.0	166.9	41.4	
			$\mu g/m^3$	**6.85**	**5.05**	**1.44**	**0.36**	

B&W/Burger April 27, 1993 (p.3 of 4)

run	side	vol. m^3	traps	uncorrected mercury (ng/trap)				
				total	ionic	methyl	Hg^o	probe
#130	SNRB out	0.1205	130		110.0	27.0	629.7 579.2 496.0	
4/30/93			backups		268.1	44.6	1.5	
14:59-18:29		blank corr total ng/spl			358.1	70.1	566.8	
			µg/m^3	**8.25**	**2.97**	**0.58**	**4.70**	
#132	ESP out	0.1460	132		902.9	306.5	lost	
4/30/93			backups		19.9	2.5	1.6	
14:39-18:48		blank corr total ng/spl			909.8	307.5	---	
			µg/m^3	**(8.70)**	**6.23**	**2.11**	**(0.36)**	

B&W/Burger April 27, 1993 (p.4of 4)

run	side	vol. m^3	traps	uncorrected mercury (ng/trap)				
				total	ionic	methyl	Hg^0	probe
trap blanks		0	309A 309B TVAB		11.0 11.3 7.8 (10.0 ± 1.9)	0.9 0.5 0.6 (0.7 ± 0.2)	1.5 ± 0.3 (n=10b/u traps)	
Anal. Blanks		0	none		4.0	0.6	0.4 0.5 0.2 0.6 0.1 (0.4 ± 0.2)	

APPENDIX B

DIOXIN/FURAN DATA REPORTING FORMS

SAMPLE NAME: R1-L5
MS FILENUMBER: S123407

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	151.4		0.77
12378-PeCDD	1384.5		1.45
123478-HxCDD	5382.6		1.32
123678-HxCDD	1132.0		1.24
123789-HxCDD	3174.9		1.24
1234678-HpCDD	14457.6		0.98
OCDD	200946.7		0.88
2378-TCDF	4818.1		0.77
12378-PeCDF	3907.2		1.36
23478-PeCDF	5126.0		1.32
123478-HxCDF	100959.6		1.28
123678-HxCDF	16445.2		1.31
123789-HxCDF	25403.9		1.23
234678-HxCDF	2049.6		1.25
1234678-HpCDF	185056.1		1.13
1234789-HpCDF	28257.2		1.03
OCDF	107066.6		0.94
Total TCDD	1345.9		0.81
Total PeCDD	7223.8		1.56
Total HxCDD	14704.2		1.26
Total HpCDD	26320.9		0.95
Total TCDF	10040.4		0.74
Total PeCDF	33950.1		1.36
Total HxCDF	305975.8		1.29
Total HpCDF	252937.7		0.97

Sample contained significant amount of particulate which appeared to impede extraction efficiency.

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO	
2378-TCDD-13C12	1114	12	1	0.76	*
12378-PeCDD-13C12	1114	11	1	1.55	*
123478-HxCDD-13C12	1114	7	1	0.98	*
123678-HxCDD-13C12	1114	41	4	1.03	*
1234678-HpCDD-13C12	1114	27	2	0.84	*
OCDD-13C12	2228	7	0	0.90	*
2378-TCDF-13C12	1114	10	1	0.80	*
12378-PeCDF-13C12	1114	5	0	1.55	*
23478-PeCDF-13C12	1114	9	1	1.45	*
123478-HxCDF-13C12	1114	1	0	0.52	*
123678-HxCDF-13C12	1114	2	0	0.43	*
123789-HxCDF-13C12	1114	7	1	0.49	*
234678-HxCDF-13C12	1114	4	0	0.62	*
1234678-HpCDF-13C12	1114	5	0	0.41	*
1234789-HpCDF-13C12	1114	3	0	0.47	*
CLEANUP STANDARD					
2378-TCDD-37Cl4	446	425	95		

* = Outside 40-120% Limit

SAMPLE NAME: R2-L5
MS FILENUMBER: S123519

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	60.0	
12378-PeCDD	0.0	75.7	
123478-HxCDD	0.0	275.2	
123678-HxCDD	0.0	107.2	
123789-HxCDD	0.0	147.7	
1234678-HpCDD	529.3		1.01
OCDD	5476.9		0.87
2378-TCDF	0.0	82.2	
12378-PeCDF	0.0	148.6	
23478-PeCDF	0.0	114.6	
123478-HxCDF	0.0	759.3	
123678-HxCDF	0.0	433.6	
123789-HxCDF	155.0		1.40
234678-HxCDF	0.0	227.0	
1234678-HpCDF	0.0	11055.1	
1234789-HpCDF	258.9		1.01
OCDF	911.9		0.83
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	137.7		1.15
Total HpCDD	915.7		0.88
Total TCDF	122.1		0.66
Total PeCDF	0.0		
Total HxCDF	155.0		
Total HpCDF	258.9		

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO	
2378-TCDD-13C12	2247	89	4	0.80	*
12378-PeCDD-13C12	2247	60	3	1.62	*
123478-HxCDD-13C12	2247	44	2	1.25	*
123678-HxCDD-13C12	2247	114	5	1.09	*
1234678-HpCDD-13C12	2247	86	4	0.98	*
OCDD-13C12	4494	50	1	0.90	*
2378-TCDF-13C12	2247	75	3	0.75	*
12378-PeCDF-13C12	2247	43	2	1.53	*
23478-PeCDF-13C12	2247	63	3	1.58	*
123478-HxCDF-13C12	2247	7	0	0.63	*
123678-HxCDF-13C12	2247	12	1	0.52	*
123789-HxCDF-13C12	2247	46	2	0.55	*
234678-HxCDF-13C12	2247	32	1	0.49	*
1234678-HpCDF-13C12	2247	39	2	0.44	*
1234789-HpCDF-13C12	2247	32	1	0.40	*
CLEANUP STANDARD					
2378-TCDD-37Cl4	899	857	95		

* = Outside 40-120% Limit

XAD-2 and filter with particulate catch split into two Soxhlet apparatus for extraction (possibly after spiking).

SAMPLE NAME: R3-L5
MS FILENUMBER: S123523

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	5.1	
12378-PeCDD	0.0	1.2	
123478-HxCDD	0.0	2.8	
123678-HxCDD	2.9		1.05
123789-HxCDD	3.7		1.43
1234678-HpCDD	29.7		1.05
OCDD	81.5		0.89
2378-TCDF	1.9		0.70
12378-PeCDF	0.0	3.3	
23478-PeCDF	1.8		1.32
123478-HxCDF	5.5		1.35
123678-HxCDF	3.0		1.22
123789-HxCDF	6.5		1.31
234678-HxCDF	0.0	2.3	
1234678-HpCDF	0.0	68.2	
1234789-HpCDF	7.5		1.04
OCDF	22.2		0.85
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	14.4		1.08
Total HpCDD	47.1		0.99
Total TCDF	10.1		0.80
Total PeCDF	13.7		1.45
Total HxCDF	19.5		1.10
Total HpCDF	22.0		0.93

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO
2378-TCDD-13C12	1096	992	91	0.79
12378-PeCDD-13C12	1096	968	88	1.63
123478-HxCDD-13C12	1096	906	83	1.01
123678-HxCDD-13C12	1096	977	89	1.01
1234678-HpCDD-13C12	1096	850	78	0.98
OCDD-13C12	2192	1416	65	0.89
2378-TCDF-13C12	1096	811	74	0.80
12378-PeCDF-13C12	1096	708	65	1.63
23478-PeCDF-13C12	1096	742	68	1.63
123478-HxCDF-13C12	1096	714	65	0.51
123678-HxCDF-13C12	1096	752	69	0.52
123789-HxCDF-13C12	1096	762	70	0.51
234678-HxCDF-13C12	1096	772	70	0.51
1234678-HpCDF-13C12	1096	733	67	0.45
1234789-HpCDF-13C12	1096	659	60	0.44
CLEANUP STANDARD				
2378-TCDD-37Cl4	438	440	100	

Sample contained significant amount of particulate and was split into two Soxhlet apparatus prior to spiking and extraction to improve extraction efficiency.

SAMPLE NAME: R1-L7
MS FILENUMBER: S123406

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	1.1	
12378-PeCDD	0.0	2.1	
123478-HxCDD	0.0	1.5	
123678-HxCDD	0.0	2.5	
123789-HxCDD	1.8		1.20
1234678-HpCDD	0.0	14.2	
OCDD	37.4		0.88
2378-TCDF	3.0		0.78
12378-PeCDF	0.0	4.9	
23478-PeCDF	1.9		1.47
123478-HxCDF	9.7		1.26
123678-HxCDF	0.0	7.6	
123789-HxCDF	3.4		1.30
234678-HxCDF	0.0	1.2	
1234678-HpCDF	0.0	61.0	
1234789-HpCDF	0.0	3.7	
OCDF	7.6		0.85
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	1.8		
Total HpCDD	0.0		
Total TCDF	12.7		0.72
Total PeCDF	1.9		
Total HxCDF	13.0		
Total HpCDF	0.0		

Second Soxhlet extractor used for *second XAD-2 resin cartridge collected.*

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO	
2378-TCDD-13C12	1013	842	83	0.77	
12378-PeCDD-13C12	1013	804	79	1.58	
123478-HxCDD-13C12	1013	803	79	1.08	
123678-HxCDD-13C12	1013	866	85	1.09	
1234678-HpCDD-13C12	1013	697	69	0.98	
OCDD-13C12	2025	1166	58	0.90	
2378-TCDF-13C12	1013	668	66	0.77	
12378-PeCDF-13C12	1013	582	58	1.53	
23478-PeCDF-13C12	1013	608	60	1.54	
123478-HxCDF-13C12	1013	136	13	0.51	*
123678-HxCDF-13C12	1013	221	22	0.53	*
123789-HxCDF-13C12	1013	630	62	0.50	
234678-HxCDF-13C12	1013	653	64	0.52	
1234678-HpCDF-13C12	1013	562	55	0.45	
1234789-HpCDF-13C12	1013	537	53	0.44	
CLEANUP STANDARD					
2378-TCDD-37Cl4	405	402	99		

* = Outside 40-120% Limit

SAMPLE NAME: R2-L7

MS FILENUMBER: S123521

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	4.0		0.78
12378-PeCDD	49.7		1.51
123478-HxCDD	119.1		1.21
123678-HxCDD	127.9		1.20
123789-HxCDD	260.8		1.25
1234678-HpCDD	1546.7		0.99
OCDD	4171.2		0.89
2378-TCDF	116.0		0.76
12378-PeCDF	94.9		1.47
23478-PeCDF	179.4		1.41
123478-HxCDF	3016.2		1.21
123678-HxCDF	461.1		1.21
123789-HxCDF	645.9		1.22
234678-HxCDF	40.3		1.11
1234678-HpCDF	3407.0		0.96
1234789-HpCDF	460.6		0.97
OCDF	2056.9		0.89
Total TCDD	29.7		0.85
Total PeCDD	184.8		1.52
Total HxCDD	960.4		1.20
Total HpCDD	2721.3		1.00
Total TCDF	245.5		0.76
Total PeCDF	828.4		1.40
Total HxCDF	6881.3		1.18
Total HpCDF	4686.6		0.95

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO	
2378-TCDD-13C12	2030	2246	111	0.77	
12378-PeCDD-13C12	2030	2591	128	1.54	
123478-HxCDD-13C12	2030	2207	109	1.16	
123678-HxCDD-13C12	2030	2354	116	1.18	
1234678-HpCDD-13C12	2030	2110	104	0.93	
OCDD-13C12	4061	3306	81	0.88	
2378-TCDF-13C12	2030	1815	89	0.78	
12378-PeCDF-13C12	2030	1475	73	1.55	
23478-PeCDF-13C12	2030	1972	97	1.55	
123478-HxCDF-13C12	2030	117	6	0.52	*
123678-HxCDF-13C12	2030	232	11	0.51	*
123789-HxCDF-13C12	2030	1822	90	0.52	
234678-HxCDF-13C12	2030	1795	88	0.51	
1234678-HpCDF-13C12	2030	1241	61	0.44	
1234789-HpCDF-13C12	2030	1736	85	0.43	
CLEANUP STANDARD					
2378-TCDD-37Cl4	812	728	90		

* = Outside 40-120% Limit

SAMPLE NAME:	R3-L7		
MS FILENUMBER:	S123605		
ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	1.7	
12378-PeCDD	0.0	2.2	
123478-HxCDD	0.0	2.6	
123678-HxCDD	0.0	2.3	
123789-HxCDD	0.0	3.4	
1234678-HpCDD	8.5		1.13
OCDD	32.3		0.93
2378-TCDF	2.6		0.73
12378-PeCDF	0.0	2.4	
23478-PeCDF	1.4		1.34
123478-HxCDF	3.4		1.09
123678-HxCDF	1.1		1.19
123789-HxCDF	2.3		0.93
234678-HxCDF	0.0	1.8	
1234678-HpCDF	0.0	80.9	
1234789-HpCDF	1.7		1.04
OCDF	7.4		0.98
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	0.0		
Total HpCDD	14.1		0.88
Total TCDF	11.7		0.84
Total PeCDF	2.7		1.67
Total HxCDF	6.8		
Total HpCDF	4.2		1.08

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO
2378-TCDD-13C12	905	870	96	0.79
12378-PeCDD-13C12	905	917	101	1.65
123478-HxCDD-13C12	905	804	89	1.13
123678-HxCDD-13C12	905	898	99	1.12
1234678-HpCDD-13C12	905	738	82	0.98
OCDD-13C12	1810	1304	72	0.90
2378-TCDF-13C12	905	707	78	0.79
12378-PeCDF-13C12	905	742	82	1.54
23478-PeCDF-13C12	905	753	83	1.56
123478-HxCDF-13C12	905	631	70	0.51
123678-HxCDF-13C12	905	663	73	0.52
123789-HxCDF-13C12	905	661	73	0.52
234678-HxCDF-13C12	905	698	77	0.52
1234678-HpCDF-13C12	905	636	70	0.44
1234789-HpCDF-13C12	905	587	65	0.43
CLEANUP STANDARD				
2378-TCDD-37Cl4	362	367	101	

SAMPLE NAME: R1-L10
MS FILENUMBER: S123408

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	28.9	
12378-PeCDD	31.5		1.60
123478-HxCDD	68.2		1.34
123678-HxCDD	96.4		1.29
123789-HxCDD	148.3		1.08
1231378-HpCDD	1110.3		0.98
OCDD	6753.5		0.88
2378-TCDF	60.9		0.71
12378-PeCDF	52.5		1.13
23478-PeCDF	66.5		1.21
123478-HxCDF	1257.7		1.12
123678-HxCDF	0.0	391.7	
123789-HxCDF	172.9		1.16
231378-HxCDF	47.2		1.31
1231378-HpCDF	0.0	5725.0	
1234789-HpCDF	333.7		0.92
OCDF	1854.5		0.93
Total TCDD	0.0		
Total PeCDD	73.2		1.51
Total HxCDD	549.3		1.35
Total HpCDD	1900.2		0.96
Total TCDF	183.6		0.87
Total PeCDF	332.8		1.28
Total HxCDF	3611.5		1.12
Total HpCDF	333.7		

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO	
2378-TCDD-13C12	1320	68	5	0.75	*
12378-PeCDD-13C12	1320	104	8	1.59	*
123478-HxCDD-13C12	1320	79	6	1.17	*
123678-HxCDD-13C12	1320	148	11	1.19	*
1234678-HpCDD-13C12	1320	101	8	0.97	*
OCDD-13C12	2640	63	2	0.88	*
2378-TCDF-13C12	1320	101	8	0.77	*
12378-PeCDF-13C12	1320	51	4	1.59	*
23478-PeCDF-13C12	1320	102	8	1.57	*
123478-HxCDF-13C12	1320	2	0	0.50	*
123678-HxCDF-13C12	1320	5	0	0.55	*
123789-HxCDF-13C12	1320	99	7	0.51	*
234678-HxCDF-13C12	1320	68	5	0.50	*
1234678-HpCDF-13C12	1320	38	3	0.41	*
1234789-HpCDF-13C12	1320	61	5	0.48	*
CLEANUP STANDARD					
2378-TCDD-37Cl4	528	518	98		

* = Outside 40-120% Limit

Sample contained significant amount of particulate which appeared to impede extraction efficiency.

SAMPLE NAME: R2-L10
MS FILENUMBER: S123520

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	18.8	
12378-PeCDD	0.0	11.9	
123478-HxCDD	0.0	31.6	
123678-HxCDD	0.0	62.1	
123789-HxCDD	40.7		1.26
1234678-HpCDD	363.2		1.03
OCDD	1665.9		0.88
2378-TCDF	8.4		0.86
12378-PeCDF	0.0	42.3	
23478-PeCDF	12.6		1.44
123478-HxCDF	0.0	271.9	
123678-HxCDF	0.0	128.1	
123789-HxCDF	27.2		1.04
234678-HxCDF	0.0	32.1	
1234678-HpCDF	0.0	5219.0	
1234789-HpCDF	92.3		0.95
OCDF	304.9		0.88
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	112.1		1.10
Total HpCDD	598.2		0.99
Total TCDF	41.0		0.83
Total PeCDF	55.1		1.53
Total HxCDF	27.2		
Total HpCDF	190.2		1.08

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO	
2378-TCDD-13C12	1533	159	10	0.81	*
12378-PeCDD-13C12	1533	169	11	1.50	*
123478-HxCDD-13C12	1533	122	8	1.24	*
123678-HxCDD-13C12	1533	190	12	1.14	*
1234678-HpCDD-13C12	1533	141	9	1.02	*
OCDD-13C12	3065	126	4	0.89	*
2378-TCDF-13C12	1533	233	15	0.79	*
12378-PeCDF-13C12	1533	67	4	1.48	*
23478-PeCDF-13C12	1533	186	12	1.57	*
123478-HxCDF-13C12	1533	3	0	0.49	*
123678-HxCDF-13C12	1533	7	0	0.58	*
123789-HxCDF-13C12	1533	169	11	0.52	*
234678-HxCDF-13C12	1533	102	7	0.50	*
1234678-HpCDF-13C12	1533	40	3	0.41	*
1234789-HpCDF-13C12	1533	85	6	0.43	*
CLEANUP STANDARD					
2378-TCDD-37Cl4	613	582	95		

* = Outside 40-120% Limit

Samples contained significant amount of particulate which appeared to impede extraction efficiency.

SAMPLE NAME: R3-L10
MS FILENUMBER: S123606

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	2.6	
12378-PeCDD	0.0	1.7	
123478-HxCDD	0.0	3.8	
123678-HxCDD	0.0	11.4	
123789-HxCDD	0.0	8.1	
1234678-HpCDD	27.4		1.03
OCDD	79.1		0.86
2378-TCDF	1.9		0.87
12378-PeCDF	0.0	2.5	
23478-PeCDF	0.0	4.5	
123478-HxCDF	4.3		1.34
123678-HxCDF	2.5		1.26
123789-HxCDF	3.9		1.28
234678-HxCDF	0.0	2.6	
1234678-HpCDF	0.0	51.3	
1234789-HpCDF	6.2		0.97
OCDF	16.0		0.92
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	0.0		
Total HpCDD	46.0		0.95
Total TCDF	11.4		0.73
Total PeCDF	0.0		
Total HxCDF	10.7		
Total HpCDF	16.0		1.03

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO
2378-TCDD-13C12	1120	999	89	0.80
12378-PeCDD-13C12	1120	1008	90	1.61
123478-HxCDD-13C12	1120	924	82	1.17
123678-HxCDD-13C12	1120	920	82	1.18
1234678-HpCDD-13C12	1120	784	70	0.94
OCDD-13C12	2241	1250	56	0.88
2378-TCDF-13C12	1120	808	72	0.79
12378-PeCDF-13C12	1120	770	69	1.55
23478-PeCDF-13C12	1120	789	70	1.56
123478-HxCDF-13C12	1120	693	62	0.51
123678-HxCDF-13C12	1120	695	62	0.52
123789-HxCDF-13C12	1120	696	62	0.52
234678-HxCDF-13C12	1120	712	64	0.51
1234678-HpCDF-13C12	1120	678	61	0.46
1234789-HpCDF-13C12	1120	648	58	0.46
CLEANUP STANDARD				
2378-TCDD-37Cl4	448	417	93	

Sample contained significant amount of particulate and was split into two Soxhlet apparatus prior to spiking and extraction to improve extraction efficiency.

SAMPLE NAME: R1-L12
MS FILENUMBER: S123518

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	1.7	
12378-PeCDD	0.0	1.5	
123478-HxCDD	0.0	4.2	
123678-HxCDD	0.0	3.4	
123789-HxCDD	3.3		1.10
1234678-HpCDD	10.7		1.19
OCDD	62.7		0.88
2378-TCDF	2.0		0.88
12378-PeCDF	0.0	3.8	
23478-PeCDF	0.0	5.2	
123478-HxCDF	17.5		1.31
123678-HxCDF	5.8		1.21
123789-HxCDF	5.0		1.26
234678-HxCDF	0.0	1.9	
1234678-HpCDF	0.0	112.8	
1234789-HpCDF	0.0	9.2	
OCDF	22.2		0.94
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	6.8		1.36
Total HpCDD	19.2		1.03
Total TCDF	10.3		0.76
Total PeCDF	0.0		
Total HxCDF	28.3		
Total HpCDF	7.0		1.06

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO	
2378-TCDD-13C12	1238	1152	93	0.79	
12378-PeCDD-13C12	1238	1074	87	1.59	
123478-HxCDD-13C12	1238	976	79	1.17	
123678-HxCDD-13C12	1238	1155	93	1.17	
1234678-HpCDD-13C12	1238	927	75	0.97	
OCDD-13C12	2477	1432	58	0.90	
2378-TCDF-13C12	1238	785	63	0.79	
12378-PeCDF-13C12	1238	608	49	1.52	
23478-PeCDF-13C12	1238	815	66	1.55	
123478-HxCDF-13C12	1238	81	7	0.51	*
123678-HxCDF-13C12	1238	146	12	0.53	*
123789-HxCDF-13C12	1238	807	65	0.52	
234678-HxCDF-13C12	1238	854	69	0.53	
1234678-HpCDF-13C12	1238	647	52	0.44	
1234789-HpCDF-13C12	1238	765	62	0.43	
CLEANUP STANDARD					
2378-TCDD-37Cl4	495	476	96		

* = Outside 40-120% Limit

SAMPLE NAME: R2-L12
MS FILENUMBER: S123522

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	9.9		0.68
12378-PeCDD	0.0	0.8	
123478-HxCDD	0.0	2.6	
123678-HxCDD	0.0	2.2	
123789-HxCDD	0.0	5.1	
1234678-HpCDD	11.7		0.91
OCDD	85.0		0.89
2378-TCDF	1.6		0.82
12378-PeCDF	0.0	2.3	
23478-PeCDF	0.0	2.8	
123478-HxCDF	4.2		1.33
123678-HxCDF	1.7		1.24
123789-HxCDF	4.3		1.30
234678-HxCDF	0.0	1.2	
1234678-HpCDF	0.0	75.5	
1234789-HpCDF	3.4		1.08
OCDF	29.8		0.93
Total TCDD	9.9		
Total PeCDD	8.2		1.62
Total HxCDD	0.0		
Total HpCDD	20.1		0.91
Total TCDF	10.7		0.84
Total PeCDF	2.0		1.34
Total HxCDF	18.3		1.23
Total HpCDF	13.0		1.01

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO
2378-TCDD-13C12	1220	1176	96	0.79
12378-PeCDD-13C12	1220	1064	87	1.61
123478-HxCDD-13C12	1220	1115	91	1.17
123678-HxCDD-13C12	1220	1233	101	1.17
1234678-HpCDD-13C12	1220	999	82	1.00
OCDD-13C12	2439	1591	65	0.87
2378-TCDF-13C12	1220	938	77	0.80
12378-PeCDF-13C12	1220	814	67	1.59
23478-PeCDF-13C12	1220	804	66	1.61
123478-HxCDF-13C12	1220	837	69	0.52
123678-HxCDF-13C12	1220	845	69	0.52
123789-HxCDF-13C12	1220	719	59	0.52
234678-HxCDF-13C12	1220	876	72	0.51
1234678-HpCDF-13C12	1220	840	69	0.47
1234789-HpCDF-13C12	1220	788	65	0.47
CLEANUP STANDARD				
2378-TCDD-37Cl4	488	486	100	

SAMPLE NAME: R3-L12
MS FILENUMBER: S123604

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	2.1	
12378-PeCDD	0.0	3.8	
123478-HxCDD	0.0	2.4	
123678-HxCDD	0.0	2.1	
123789-HxCDD	0.0	3.4	
1234678-HpCDD	9.5		0.99
OCDD	68.8		0.79
2378-TCDF	0.0	2.4	
12378-PeCDF	0.0	1.5	
23478-PeCDF	0.0	1.9	
123478-HxCDF	0.0	5.9	
123678-HxCDF	1.3		1.25
123789-HxCDF	3.3		1.04
234678-HxCDF	0.0	2.4	
1234678-HpCDF	0.0	117.3	
1234789-HpCDF	2.9		1.02
OCDF	19.0		0.89
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	0.0		
Total HpCDD	16.7		1.02
Total TCDF	2.3		0.66
Total PeCDF	0.0		
Total HxCDF	6.2		1.07
Total HpCDF	10.6		1.15

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO
2378-TCDD-13C12	1258	1183	94	0.79
12378-PeCDD-13C12	1258	1207	96	1.51
123478-HxCDD-13C12	1258	1083	86	1.13
123678-HxCDD-13C12	1258	1182	94	1.15
1234678-HpCDD-13C12	1258	956	76	0.86
OCDD-13C12	2516	1714	68	0.90
2378-TCDF-13C12	1258	943	75	0.80
12378-PeCDF-13C12	1258	924	73	1.62
23478-PeCDF-13C12	1258	930	74	1.63
123478-HxCDF-13C12	1258	839	67	0.51
123678-HxCDF-13C12	1258	859	68	0.52
123789-HxCDF-13C12	1258	853	68	0.51
234678-HxCDF-13C12	1258	928	74	0.52
1234678-HpCDF-13C12	1258	837	67	0.43
1234789-HpCDF-13C12	1258	822	65	0.43
CLEANUP STANDARD				
2378-TCDD-37Cl4	503	499	99	

SAMPLE NAME: MATRIX SPIKE

MS FILENUMBER: S123607

ANALYTE	CONC. FOUND (pg/dscm)	SPIKE LEVEL (pg/dscm)	PERCENT RECOVERY	ION RATIO
2378-TCDD	186.9	200.0	93.5	0.75
12378-PeCDD	919.9	1000.0	92.0	1.58
123478-HxCDD	820.6	1000.0	82.1	1.24
123678-HxCDD	780.1	1000.0	78.0	1.27
123789-HxCDD	711.1	1000.0	71.1	1.23
1234678-HpCDD	862.5	1000.0	86.2	1.06
OCDD	1877.7	2000.0	93.9	0.90
2378-TCDF	185.9	200.0	92.9	0.76
12378-PeCDF	945.4	1000.0	94.5	1.37
23478-PeCDF	881.5	1000.0	88.1	1.42
123478-HxCDF	894.6	1000.0	89.5	1.24
123678-HxCDF	892.4	1000.0	89.2	1.23
123789-HxCDF	892.7	1000.0	89.3	1.22
234678-HxCDF	926.2	1000.0	92.6	1.27
1234678-HpCDF	850.4	1000.0	85.0	1.03
1234789-HpCDF	970.7	1000.0	97.1	0.99
OCDF	2081.8	2000.0	104.1	0.90
Total TCDD	186.9			
Total PeCDD	919.9			
Total HxCDD	2311.8			
Total HpCDD	862.5			
Total TCDF	185.9			
Total PeCDF	1826.9			
Total HxCDF	3605.9			
Total HpCDF	1821.2			

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO
2378-TCDD-13C12	2000	1450	72	0.79
12378-PeCDD-13C12	2000	1636	82	1.58
123478-HxCDD-13C12	2000	1585	79	1.22
123678-HxCDD-13C12	2000	1655	83	1.20
1234678-HpCDD-13C12	2000	1143	57	0.98
OCDD-13C12	4000	1437	36	0.89
2378-TCDF-13C12	2000	1360	68	0.79
12378-PeCDF-13C12	2000	1194	60	1.55
23478-PeCDF-13C12	2000	1400	70	1.57
123478-HxCDF-13C12	2000	1186	59	0.52
123678-HxCDF-13C12	2000	1229	61	0.52
123789-HxCDF-13C12	2000	1199	60	0.52
234678-HxCDF-13C12	2000	898	45	0.53
1234678-HpCDF-13C12	2000	1048	52	0.45
1234789-HpCDF-13C12	2000	955	48	0.44
CLEANUP STANDARD				
2378-TCDD-37Cl4	800	743	93	

* = Outside 40-120% Limit

SAMPLE NAME: METHOD BLANK
MS FILENUMBER: S123403

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	4.5	
12378-PeCDD	0.0	1.8	
123478-HxCDD	0.0	2.4	
123678-HxCDD	0.0	1.4	
123789-HxCDD	0.0	5.7	
1234678-HpCDD	0.0	10.0	
OCDD	69.2		0.84
2378-TCDF	0.0	1.9	
12378-PeCDF	0.0	3.1	
23478-PeCDF	0.0	2.3	
123478-HxCDF	0.0	36.5	
123678-HxCDF	0.0	17.4	
123789-HxCDF	0.0	10.0	
234678-HxCDF	0.0	2.1	
1234678-HpCDF	0.0	19.7	
1234789-HpCDF	0.0	3.0	
OCDF	0.0	11.3	
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	0.0		
Total HpCDD	0.0		
Total TCDF	0.0		
Total PeCDF	0.0		
Total HxCDF	0.0		
Total HpCDF	0.0		

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO	
2378-TCDD-13C12	2000	1799	90	0.78	
12378-PeCDD-13C12	2000	1638	82	1.53	
123478-HxCDD-13C12	2000	1527	76	1.19	
123678-HxCDD-13C12	2000	1654	83	1.20	
1234678-HpCDD-13C12	2000	1297	65	1.01	
OCDD-13C12	4000	1365	34	0.90	*
2378-TCDF-13C12	2000	1464	73	0.79	
12378-PeCDF-13C12	2000	890	44	1.53	
23478-PeCDF-13C12	2000	1282	64	1.58	
123478-HxCDF-13C12	2000	54	3	0.46	*
123678-HxCDF-13C12	2000	113	6	0.50	*
123789-HxCDF-13C12	2000	1301	65	0.53	
234678-HxCDF-13C12	2000	1188	59	0.53	
1234678-HpCDF-13C12	2000	765	38	0.45	*
1234789-HpCDF-13C12	2000	1117	56	0.44	
CLEANUP STANDARD					
2378-TCDD-37Cl4	800	796	99		

* = Outside 40-120% Limit

SAMPLE NAME: FIELD BLANK-L7
MS FILENUMBER: S123405

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	1.9	
12378-PeCDD	0.0	1.1	
123478-HxCDD	0.0	0.9	
123678-HxCDD	0.0	0.8	
123789-HxCDD	0.0	2.4	
1234678-HpCDD	0.0	12.1	
OCDD	49.9		0.86
2378-TCDF	0.0	1.5	
12378-PeCDF	0.0	1.3	
23478-PeCDF	0.0	1.3	
123478-HxCDF	0.0	7.3	
123678-HxCDF	0.0	4.1	
123789-HxCDF	2.6		1.37
234678-HxCDF	0.0	1.5	
1234678-HpCDF	0.0	24.2	
1234789-HpCDF	0.0	1.3	
OCDF	3.7		0.95
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	0.0		
Total HpCDD	0.0		
Total TCDF	6.4		0.74
Total PeCDF	0.0		
Total HxCDF	2.6		
Total HpCDF	0.0		

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO	
2378-TCDD-13C12	2000	1651	83	0.79	
12378-PeCDD-13C12	2000	1699	85	1.59	
123478-HxCDD-13C12	2000	1621	81	1.12	
123678-HxCDD-13C12	2000	1623	81	1.12	
1234678-HpCDD-13C12	2000	1421	71	0.98	
OCDD-13C12	4000	2420	60	0.91	
2378-TCDF-13C12	2000	1327	66	0.77	
12378-PeCDF-13C12	2000	1268	63	1.54	
23478-PeCDF-13C12	2000	1315	66	1.53	
123478-HxCDF-13C12	2000	339	17	0.53	*
123678-HxCDF-13C12	2000	579	29	0.53	*
123789-HxCDF-13C12	2000	1241	62	0.52	
234678-HxCDF-13C12	2000	1310	66	0.54	
1234678-HpCDF-13C12	2000	1220	61	0.47	
1234789-HpCDF-13C12	2000	1142	57	0.47	
CLEANUP STANDARD					
2378-TCDD-37Cl4	800	790	99		

* = Outside 40-120% Limit

SAMPLE NAME: FIELD BLANK-L12
MS FILENUMBER: S123404

ANALYTE	CONC. FOUND (pg/dscm)	DETECTION LIMIT (pg/dscm)	ION RATIO
2378-TCDD	0.0	2.7	
12378-PeCDD	0.0	6.6	
123478-HxCDD	0.0	8.6	
123678-HxCDD	0.0	5.7	
123789-HxCDD	0.0	16.3	
1234678-HpCDD	0.0	15.0	
OCDD	47.0		0.86
2378-TCDF	0.0	1.8	
12378-PeCDF	0.0	15.3	
23478-PeCDF	0.0	2.9	
123478-HxCDF	0.0	359.9	
123678-HxCDF	0.0	423.8	
123789-HxCDF	0.0	6.9	
234678-HxCDF	0.0	1.2	
1234678-HpCDF	0.0	2159.0	
1234789-HpCDF	0.0	4.6	
OCDF	0.0	3.2	
Total TCDD	0.0		
Total PeCDD	0.0		
Total HxCDD	0.0		
Total HpCDD	0.0		
Total TCDF	0.0		
Total PeCDF	0.0		
Total HxCDF	0.0		
Total HpCDF	0.0		

LABELED COMPOUNDS	SPIKE CONC. (pg/dscm)	CONC. FOUND (pg/dscm)	PERCENT RECOVERY	ION RATIO	
2378-TCDD-13C12	2000	1768	88	0.77	
12378-PeCDD-13C12	2000	609	30	1.59	*
123478-HxCDD-13C12	2000	262	13	1.07	*
123678-HxCDD-13C12	2000	374	19	1.18	*
1234678-HpCDD-13C12	2000	1166	58	1.01	
OCDD-13C12	4000	2308	58	0.88	
2378-TCDF-13C12	2000	1368	68	0.79	
12378-PeCDF-13C12	2000	162	8	1.68	*
23478-PeCDF-13C12	2000	610	30	1.60	*
123478-HxCDF-13C12	2000	4	0	0.43	*
123678-HxCDF-13C12	2000	4	0	0.50	*
123789-HxCDF-13C12	2000	1207	60.	0.52	
234678-HxCDF-13C12	2000	1308	65	0.52	
1234678-HpCDF-13C12	2000	9	0	0.51	*
1234789-HpCDF-13C12	2000	357	18	0.45	
CLEANUP STANDARD					
2378-TCDD-37Cl4	800	796	100		

* = Outside 40-120% Limit

APPENDIX C

RADIONUCLIDE ANALYSIS RESULTS

'he following deliverable, Work Order Number S3-07-040, is being relinquished to yo
y the reporting department of International Technology Corporation - Oak Ridge, 1550 Bea
Creek Road, Kingston, Tennessee 37763.

- [ ] Radiological Report w/Data Package
- [x] Radiological Report w/Certificate of Analysis AMENDED Report
- [ ] CLP Sample Data Summary w/EDT Hardcopy
- [ ] CLP Volatile Data Package
- [ ] CLP Semivolatile Data Package
- [ ] CLP Pesticide/PCB Data Package
- [ ] CLP Herbicide Data Package
- [ ] CLP Inorganics Data Package
- [ ] Certificate of Analysis Only
- [ ] EDT Hardcopy Report w/complimentary COA
- [ ] EDT Floppy Diskette
- [ ] Other____________________

Relinquished By:	Date:	Received By:	Date:
Bettye Vetator	9-9-93		

lease sign the following Chain of Custody and return it to International Technology - Oak
idge, 1550 Bear Creek Road, Kingston, Tennessee 37763, Attention: Reporting.

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

BATTELLE MEMORIAL INSTITUTE
505 King Avenue
Columbus, Ohio 43201

Date: September 9, 1993

ATTN: Karen Riggs

Work Order: S3-07-040 **(Amended Report)**

This is the Certificate of Analysis for the following samples:

Client Project ID:	93-1032-SLA
Date Received By Lab:	July 16, 1993
Number of Samples:	Eighteen (18)
Sample Type:	Filter

I. INTRODUCTION

On July 16, 1993, eighteen (18) filter samples were received at ITAS-Oak Ridge, Tennessee laboratory from Battelle Memorial Institute, Columbus, Ohio. The list of analytical tests performed as well as date of receipt and analysis can be found in the attached report.

The report is amended to correct the U-235 result for sample (11) 156124.

The samples were labeled as follows:

CLIENT SAMPLE ID	ITAS SAMPLE NUMBER	PARAMETERS REQUIRED
150904	S3-07-040-01	List One
150908	S3-07-040-02	List One
150900	S3-07-040-03	List One
155546	S3-07-040-04	List One
156101	S3-07-040-05	List One

Reviewed and Approved:

Jamie Bates
for James M. Littlefield
Radiologic Analysis Group Leader

Reviewed and Approved:

Susan Aderholdt
Susan Aderholdt
Project Manager

JML/bav

Any reproductions must be made of the complete data report.

I. INTRODUCTION (Continued)

The samples were labeled as follows:

CLIENT SAMPLE ID	ITAS SAMPLE NUMBER	PARAMETERS REQUIRED
155513	S3-07-040-06	List One
155521	S3-07-040-07	List One
156120	S3-07-040-08	List One
155538	S3-07-040-09	List One
155550	S3-07-040-10	List One
156124	S3-07-040-11	List One
155517	S3-07-040-12	List One
155554	S3-07-040-13	List One
155509	S3-07-040-14	List One
156103	S3-07-040-15	List One
156102	S3-07-040-16	List One
155503	S3-07-040-17	List One
155542	S3-07-040-18	List One
DUP 150904	S3-07-040-19	List One
BLANK RESULTS	S3-07-040-20	List Two
SPIKE RESULTS	S3-07-040-21	List Two

List One consists of: Lead 210, Radium 226, Radium 228, Thorium 230, Uranium 234, Uranium 235 and Uranium 238.

List Two consists of: Cesium 137.

II. ANALYTICAL RESULTS/METHODOLOGY

The analytical results for this report are presented by analytical tests. Each set of data will include sample identification, analytical results, and/or the appropriate detection limits.

The analytical results reported relate only to those items tested.

The samples were prepared for Gamma Spectrometry using ITAS Oak Ridge Standard Operating Procedure OR-7003, Revision 0 and counted using ITAS Oak Ridge Standard Operating Procedure OR-7212, Revision 0.

III. QUALITY CONTROL

QA/QC information was performed on the enclosed analytical data. The purpose of QA/QC information is to ensure the user that the data enclosed is scientifically valid and is used to assess the laboratory's performance.

IV. NONCONFORMANCE

There were no nonconformances associated with this work order.

V. COMMENTS

Gamma Spectrometry Analysis:

The client requested Thorium 232 and Thorium 228 to be analyzed by Gamma Spectrometry. These isotopes are being reported as Radium 228. The client also requested Polonium 210 to be analyzed by Gamma Spectrometry. This isotope is being reported as Lead 210. This is based on the assumption that the Thorium and Radium and the Polonium and Lead are in secular equilibrium.

Uranium 238 is being reported from the 63 keV energy line from the Thorium 234 assuming that the Uranium 238 and Thorium 234 are in secular equilibrium.

Analysis For Samples 8-12 and 17:

Samples (08) 156120 through (12) 155517 and (17) 155503 were part of a larger set submitted to the count room on August 9, 1993. At the direction of the Technical Director the count room was requested to retain the QC (QC #93-7188) from the larger set to run with this subset. The special instructions were followed exactly with additional repetition of the microwave digestion step and a final attempt to microwave using 10 mls each $HF/HNO_3/HCl$. All attempts to get the samples into solution were unsuccessful. The Technical Director finally directed that the samples were to be suspended in a gel agent.

ived: 07/16/93 Results by Sample

LE ID 150904 FRACTION 01A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	<1.1E+2		pCi/sample
RA-226	<1.2E+1		pCi/sample
RA-228	<2.9E+1		pCi/sample
TH-230	<5.2E+2		pCi/sample
U-234	<2.3E+3		pCi/sample
U-235	<2.2E+1		pCi/sample
U-238	2.38E+2	0.72E+2	pCi/sample

Received: 07/16/93
Results by Sample

SAMPLE ID 150908 FRACTION 02A TEST CODE ASIRPT NAME Form to report data

Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	1.63E+2	0.64E+2	pCi/sample
RA-226	<1.4E+1		pCi/sample
RA-228	<2.7E+1		pCi/sample
TH-230	<5.7E+2		pCi/sample
U-234	<2.5E+3		pCi/sample
U-235	<2.4E+1		pCi/sample
U-238	2.06E+2	0.69E+2	pCi/sample

LE ID 150900 FRACTION 03A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	9.76E+1	7.36E+1	pCi/sample
RA-226	<1.3E+1		pCi/sample
RA-228	<2.4E+1		pCi/sample
TH-230	<6.3E+2		pCi/sample
U-234	<2.5E+3		pCi/sample
U-235	<2.5E+1		pCi/sample
U-238	1.94E+2	0.70E+2	pCi/sample

Received: 07/16/93
Results by Sample

SAMPLE ID 155546 FRACTION 04A TEST CODE ASIRPT NAME Form to report data

Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	2.29E+2	0.85E+2	pCi/sample
RA-226	<1.2E+1		pCi/sample
RA-228	<2.7E+1		pCi/sample
TH-230	<6.1E+2		pCi/sample
U-234	<2.4E+3		pCi/sample
U-235	<2.4E+1		pCi/sample
U-238	1.76E+2	0.62E+2	pCi/sample

ived: 07/16/93 Results by Sample

LE ID 156101 FRACTION 05A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	1.67E+2	0.79E+2	pCi/sample
RA-226	<1.2E+1		pCi/sample
RA-228	<2.8E+1		pCi/sample
TH-230	<5.6E+2		pCi/sample
U-234	<2.6E+3		pCi/sample
U-235	<2.4E+1		pCi/sample
U-238	2.20E+2	0.68E+2	pCi/sample

Received: 07/16/93
Results by Sample

SAMPLE ID 155513 FRACTION 06A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	1.66E+2	0.75E+2	pCi/sample
RA-226	<1.4E+1		pCi/sample
RA-228	<2.5E+1		pCi/sample
TH-230	<6.4E+2		pCi/sample
U-234	<2.5E+3		pCi/sample
U-235	<2.7E+1		pCi/sample
U-238	2.14E+2	0.61E+2	pCi/sample

LE ID 155521 FRACTION 07A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	1.85E+2	0.84E+2	pCi/sample
RA-226	1.16E+1	0.60E+1	pCi/sample
RA-228	<2.6E+1		pCi/sample
TH-230	<6.4E+2		pCi/sample
U-234	<2.7E+3		pCi/sample
U-235	<2.5E+1		pCi/sample
U-238	2.42E+2	0.75E+2	pCi/sample

Received: 07/16/93 Results by Sample

SAMPLE ID 156120 FRACTION 08A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	<2.8E+1		pCi/g
RA-226	<2.5E+0		pCi/g
RA-228	<6.3E+0		pCi/g
TH-230	<1.4E+2		pCi/g
U-234	<5.3E+2		pCi/g
U-235	<5.4E+0		pCi/g
U-238	4.49E+1	1.36E+1	pCi/g

LE ID 155538 FRACTION 09A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	<2.2E+1		pCi/g
RA-226	<2.9E+0		pCi/g
RA-228	<5.6E+0		pCi/g
TH-230	<1.3E+2		pCi/g
U-234	<5.2E+2		pCi/g
U-235	<4.8E+0		pCi/g
U-238	4.52E+1	1.33E+1	pCi/g

SAMPLE ID 155550 FRACTION 10A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	<2.1E+1		pCi/g
RA-226	1.66E+0	1.36E+0	pCi/g
RA-228	<5.8E+0		pCi/g
TH-230	<1.3E+2		pCi/g
U-234	<4.8E+2		pCi/g
U-235	<5.6E+0		pCi/g
U-238	4.86E+1	1.26E+1	pCi/g

LE ID 156124 FRACTION 11A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	<2.7E+1		pCi/g
RA-226	<2.9E+0		pCi/g
RA-228	<5.7E+0		pCi/g
TH-230	<1.2E+2		pCi/g
U-234	<5.1E+2		pCi/g
U-235	<4.8E+0		pCi/g
U-238	4.09E+1	1.25E+1	pCi/g

Received: 07/16/93 Results by Sample

SAMPLE ID 155517 FRACTION 12A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	<2.7E+1		pCi/g
RA-226	1.34E+0	1.32E+0	pCi/g
RA-228	<5.6E+0		pCi/g
TH-230	<1.2E+2		pCi/g
U-234	<5.2E+2		pCi/g
U-235	<5.1E+0		pCi/g
U-238	5.20E+1	1.42E+1	pCi/g

ived: 07/16/93 Results by Sample

LE ID 155554 FRACTION 13A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	2.06E+2	0.78E+2	pCi/sample
RA-226	<1.4E+1		pCi/sample
RA-228	<2.5E+1		pCi/sample
TH-230	<5.8E+2		pCi/sample
U-234	<2.5E+3		pCi/sample
U-235	<2.5E+1		pCi/sample
U-238	2.16E+2	0.60E+2	pCi/sample

SAMPLE ID 155509 FRACTION 14A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	3.04E+0	0.89E+0	pCi/g
RA-226	1.13E+0	0.21E+0	pCi/g
RA-228	7.95E-1	2.65E-1	pCi/g
TH-230	<1.1E+1		pCi/g
U-234	<2.9E+1		pCi/g
U-235	<3.8E-1		pCi/g
U-238	5.52E+0	1.30E+0	pCi/g

NF

.E ID 156103 FRACTION 15A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	3.24E+0	0.98E+0	pCi/g
RA-226	8.52E-1	1.93E-1	pCi/g
RA-228	8.92E-1	2.87E-1	pCi/g
TH-230	<1.0E+1		pCi/g
U-234	<3.4E+1		pCi/g
U-235	3.71E-1	2.47E-1	pCi/g
U-238	4.71E+0	1.22E+0	pCi/g

SAMPLE ID 156102 FRACTION 16A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	1.29E+2	0.78E+2	pCi/sample
RA-226	<1.3E+1		pCi/sample
RA-228	<2.0E+1		pCi/sample
TH-230	<6.2E+2		pCi/sample
U-234	<2.5E+3		pCi/sample
U-235	<2.2E+1		pCi/sample
U-238	2.14E+2	0.70E+2	pCi/sample

ived: 07/16/93 Results by Sample

LE ID 155503 FRACTION 17A TEST CODE ASIRPT NAME Form to report data

Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	<3.2E+1		pCi/g
RA-226	2.63E+0	1.80E+0	pCi/g
RA-228	<5.5E+0		pCi/g
TH-230	<1.3E+2		pCi/g
U-234	<5.6E+2		pCi/g
U-235	<5.1E+0		pCi/g
U-238	3.76E+1	1.17E+1	pCi/g

Received: 07/16/93 Results by Sample

SAMPLE ID 155542 FRACTION 18A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	3.17E+0	0.88E+0	pCi/g
RA-226	9.27E-1	2.01E-1	pCi/g
RA-228	6.74E-1	2.72E-1	pCi/g
TH-230	<9.2E+0		pCi/g
U-234	<3.4E+1		pCi/g
U-235	3.82E-1	2.43E-1	pCi/g
U-238	4.76E+0	1.22E+0	pCi/g

ived: 07/16/93 Results by Sample

.E ID DUP 150904 FRACTION 19A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category FILTER

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	1.65E+2	0.76E+2	pCi/sample
RA-226	<1.3E+1		pCi/sample
RA-228	<2.5E+1		pCi/sample
TH-230	<6.1E+2		pCi/sample
U-234	<2.5E+3		pCi/sample
U-235	<2.3E+1		pCi/sample
U-238	2.40E+2	0.61E+2	pCi/sample

Received: 07/16/93
Results by Sample

SAMPLE ID BLANK RESULTS FRACTION 20A TEST CODE ASIRPT NAME Form to report data

Date & Time Collected not specified Category LIQUID

PARAMETER		RESULT	2-SIGMA ERROR	UNITS
B93-7188-A	CS-137	1.58E+1		DPM
B93-7188-B	CS-137	1.58E+1		DPM

.E ID SPIKE RESULTS FRACTION 21A TEST CODE SPK NAME Report Form Spiked Samples
Date & Time Collected not specified Category LIQUID

UNITS DPM

PARAMETER	RESULT
S93-7188-A CS-137	
KNOWN	4.07E+5
FOUND	4.20E+5
NORMALIZED DEVIATION (IN SIGMA)	0.64
S93-7188-B CS-137	
KNOWN	4.07E+5
FOUND	4.21E+5
NORMALIZED DEVIATION (IN SIGMA)	0.69

BATTELLE MEMORIAL INSTITUTE

GAMMA SPECTROMETRY

PREPARED: 08/09/93, 08/16/93
ANALYZED: 08/17/93, 08/18/93

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

CERTIFICATE OF ANALYSIS

BATTELLE MEMORIAL INSTITUTE
505 King Avenue
Columbus, Ohio 43201

Date: August 18, 1993

ATTN: Karen Riggs

Work Order: S3-07-023

This is the Certificate of Analysis for the following samples:

Client Project ID: 58073/931032-SLA
Date Received By Lab: 07/09/93
Number of Samples: Three (3)
Sample Type: Solid

I. INTRODUCTION

On July 9, 1993, three (3) solid samples were received at ITAS-Oak Ridge, Tennessee laboratory from Battelle Columbus Division, Columbus, Ohio. The list of analytical tests performed as well as date of receipt and analysis can be found in the attached report.

The samples were labeled as follows:

CLIENT SAMPLE ID	ITAS SAMPLE NUMBER	PARAMETERS REQUIRED
APR2693COAL	S3-07-023-01	List One
MAY0193COAL	S3-07-023-02	List One
MAY0293COAL	S3-07-023-03	List One
DUP APR2693COAL	S3-07-023-04	List One
BLANK RESULTS	S3-07-023-05	List Two
SPIKE RESULTS	S3-07-023-06	List Two

Reviewed and Approved:

James M. Littlefield
Radiologic Analysis Group Leader

Reviewed and Approved:

Susan Aderholdt
Project Manager

JML/bav

I. INTRODUCTION (Continued)

List One consists of: Lead 210, Radium 226, Radium 228, Thorium 230, Uranium 234, Uranium 235 and Uranium 238.

List Two consists of: Cesium 137.

II. ANALYTICAL RESULTS/METHODOLOGY

The analytical results for this report are presented by analytical tests. Each set of data will include sample identification, analytical results, data package including the raw data, and/or the appropriate detection limits.

The analytical results reported relate only to those items tested.

The samples were prepared for Gamma Spectrometry using ITAS Oak Ridge Standard Operating Procedure OR-7003, Revision 0 and counted using ITAS Oak Ridge Standard Operating Procedure OR-7212, Revision 0.

III. QUALITY CONTROL

QA/QC information was performed on the enclosed analytical data. The purpose of QA/QC information is to ensure the user that the data enclosed is scientifically valid and is used to assess the laboratory's performance.

IV. NONCONFORMANCE

There were no nonconformances associated with this work order.

V. COMMENTS

Gamma Spectrometry Analysis:

The client requested Thorium 232 and Thorium 228 to be analyzed by Gamma Spectrometry. These isotopes are being reported as Radium 228. The client also requested Polonium 210 to be analyzed by Gamma Spectrometry. This isotope is being reported as Lead 210. This is based on the assumption that the Thorium and Radium and the Polonium and Lead are in secular equilibrium.

Uranium 238 is being reported from the 63 keV energy line from the Thorium 234 assuming that the Uranium 238 and Thorium 234 are in secular equilibrium.

ived: 07/09/93 Results by Sample

LE ID APR2693COAL FRACTION 01A TEST CODE ASIRPT NAME Form to report data

Date & Time Collected not specified Category COAL

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	4.37E-1	3.63E-1	pCi/g
RA-226	2.26E-1	0.58E-1	pCi/g
RA-228	2.26E-1	1.01E-1	pCi/g
TH-230	<4.0E+0		pCi/g
U-234	<1.3E+1		pCi/g
U-235	<1.5E-1		pCi/g
U-238	4.93E-1	4.13E-1	pCi/g

Received: 07/09/93 Results by Sample

SAMPLE ID MAY0193COAL FRACTION 02A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category COAL

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	<4.3E-1		pCi/g
RA-226	2.80E-1	0.57E-1	pCi/g
RA-228	2.25E-1	0.81E-1	pCi/g
TH-230	<3.9E+0		pCi/g
U-234	<1.3E+1		pCi/g
U-235	<1.4E-1		pCi/g
U-238	<5.7E-1		pCi/g

'LE ID MAY0293COAL FRACTION 03A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category COAL

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	<5.0E-1		pCi/g
RA-226	2.92E-1	0.59E-1	pCi/g
RA-228	2.49E-1	0.90E-1	pCi/g
TH-230	<4.0E+0		pCi/g
U-234	<1.3E+1		pCi/g
U-235	<1.8E-1		pCi/g
U-238	3.77E-1	3.67E-1	pCi/g

Received: 07/09/93 Results by Sample

SAMPLE ID DUP APR2693COAL FRACTION 04A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category COAL

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
PB-210	<4.8E-1		pCi/g
RA-226	2.40E-1	0.56E-1	pCi/g
RA-228	2.53E-1	1.02E-1	pCi/g
TH-230	<4.0E+0		pCi/g
U-234	<1.3E+1		pCi/g
U-235	<1.4E-1		pCi/g
U-238	<5.3E-1		pCi/g

ived: 07/09/93 Results by Sample

LE ID BLANK RESULTS FRACTION 05A TEST CODE ASIRPT NAME Form to report data
Date & Time Collected not specified Category LIQUID

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
B93-7186 CS-137	2.0E+1		DPM

Received: 07/09/93
Results by Sample

SAMPLE ID SPIKE RESULTS FRACTION 06A TEST CODE ASIRPT NAME Form to report data

Date & Time Collected not specified Category LIQUID

PARAMETER	RESULT	2-SIGMA ERROR	UNITS
S93-7186 CS-137			
KNOWN	2.15E+5		DPM
FOUND	2.36E+5		DPM
NORMALIZED DEVIATION (IN SIGMA)	1.95		

TELLE MEMORIAL INSTITUTE

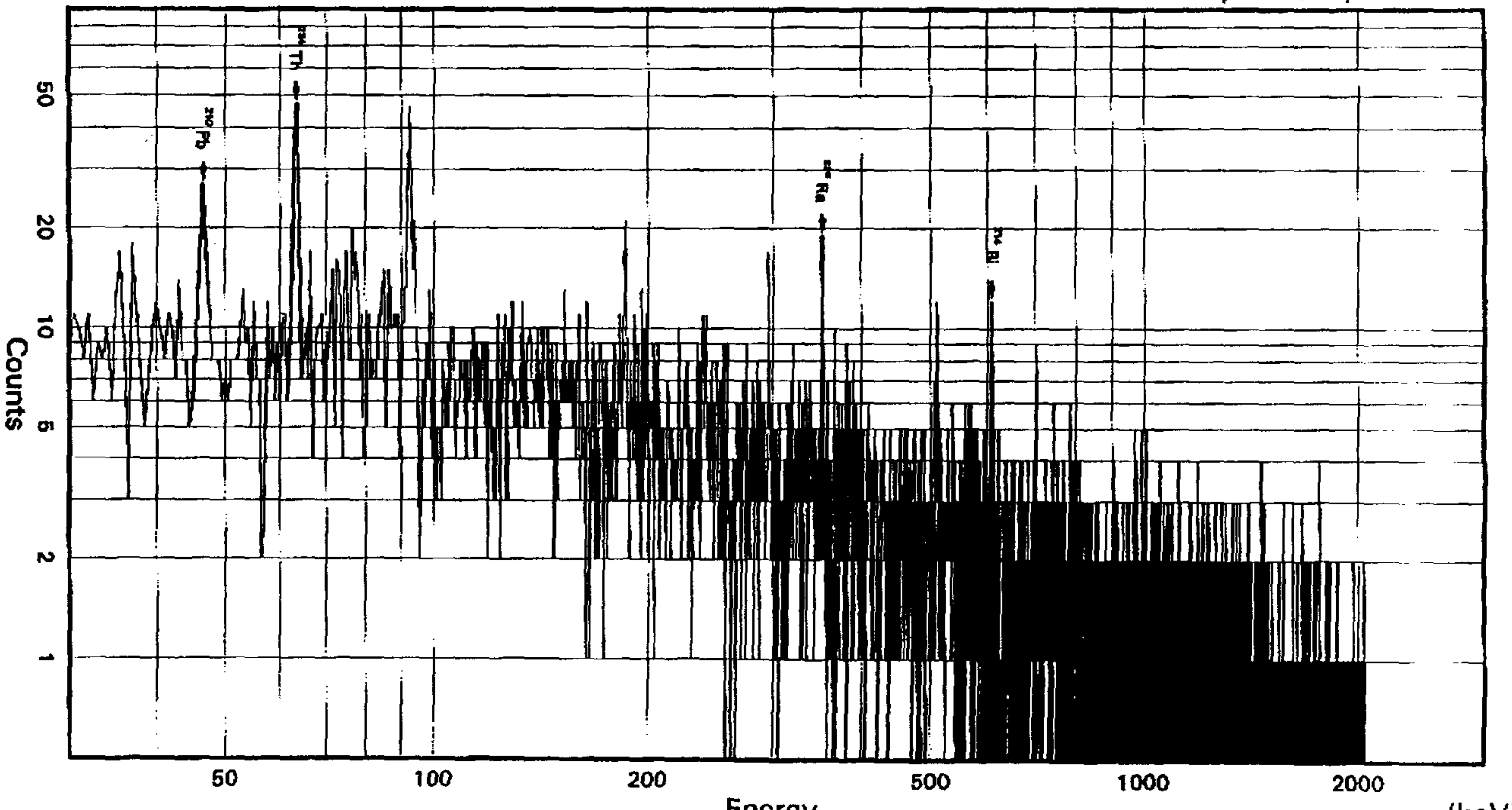
MA SPECTROMETRY

?ARED: 08/03/93
.YZED: 08/17/93

IT Corporation Oak Ridge Laboratory
Gamma Spectroscopy

Sample ID: B-93-7186
Batch ID: 93-7186

Detector ID: GE 2
Analysis Library: MAIN



Sample Taken: 17-AUG-1993 00:00:00.00
Acquisition Start: 17-AUG-1993 11:36:19.16
Preset Live Time: 0 01:00:00.00
Elapsed Live Time: 0 01:00:00.00

Calibration Parameters
Offset: -5.78101E-02
Slope: 4.99916E-01
Quadrature: 1.04469E-08

ITAS Oak Ridge Laboratory
Gamma Spectroscopic Analysis
(OR-7003)

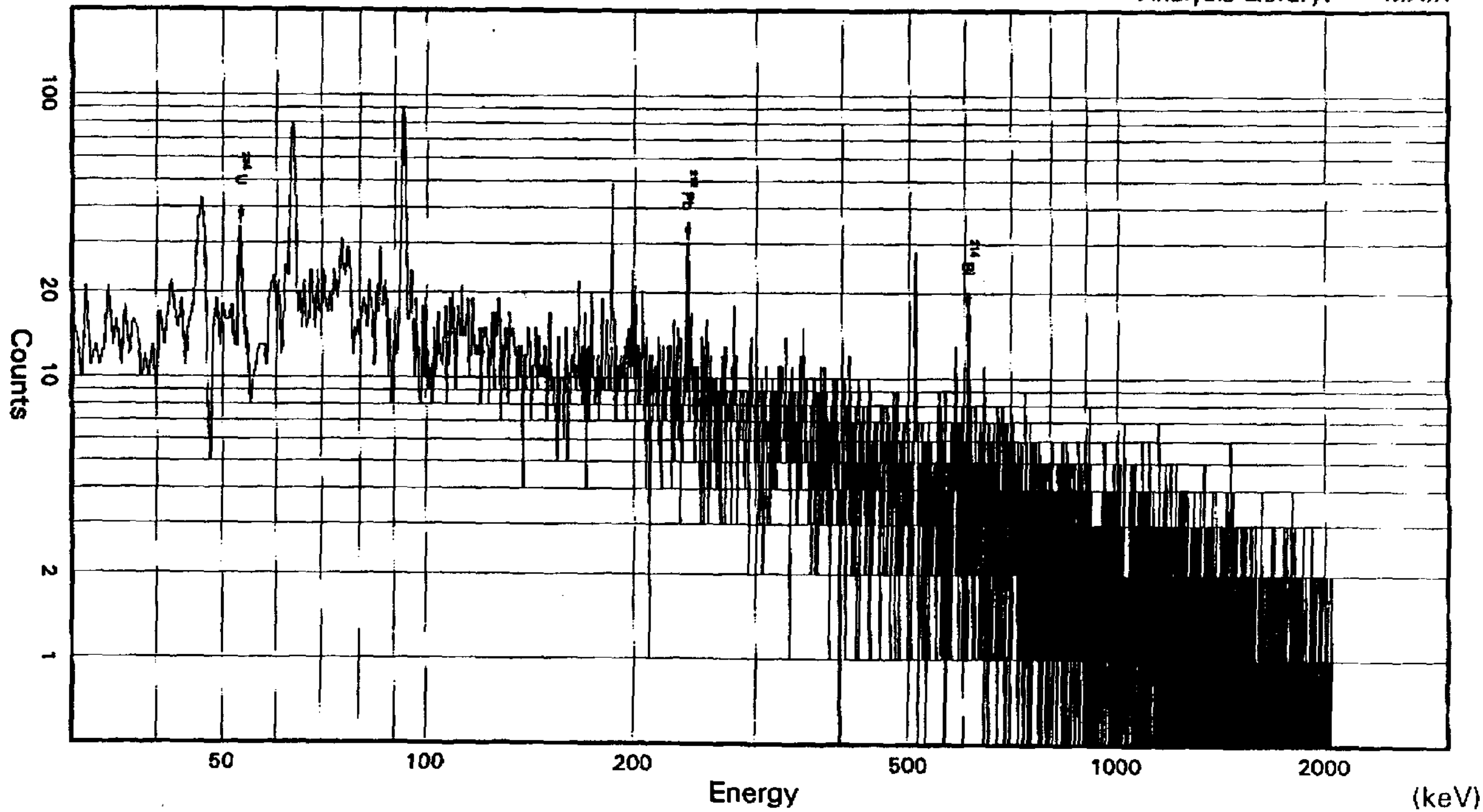
port 2: Summary of Positively Identified Nuclides Page: 1
mple ID: B-93-7186 Acquisition Date : 17-AUG-1993 11:36:19

Nuclide Name	Lc (pCi / gram)	Ld	Lq	Activity	2-Sigma Error
BI-214	1.3E-02	2.9E-02	1.7E-01	4.82E-02	2.50E-02 (52%)
RA-226	1.0E-02	2.3E-02	1.4E-01	1.97E-02	1.75E-02 (89%)
TH-234	8.7E-02	1.9E-01	8.7E-01	0.18E-01	1.50E-01 (828%)

IT Corporation Oak Ridge Laboratory
Gamma Spectroscopy

Sample ID: B-93-7188
Batch ID: 93-7188

Detector ID: GE 2
Analysis Library: MAIN



Sample Taken: 19-AUG-1993 00:00:00.00
Acquisition Start: 19-AUG-1993 08:33:51.76
Preset Live Time: 0 02:00:00.00
Elapsed Live Time: 0 02:00:00.00

Calibration Parameters
Offset: -5.78101E-02
Slope: 4.99916E-01
Quadrature: 1.04469E-08

ITAS Oak Ridge Laboratory
Gamma Spectroscopic Analysis
(OR-7003)

port 2: Summary of Positively Identified Nuclides Page: 1
mple ID: B-93-7188 Acquisition Date : 19-AUG-1993 08:33:51

Nuclide Name	(pCi / Liter) Lc	Ld	Lq	Activity	2-Sigma Error
PB-212	6.8E+00	1.5E+01	6.7E+01	0.09E+01	1.01E+01 (---%)
BI-214	1.2E+01	2.6E+01	1.4E+02	1.48E+01	1.95E+01 (132%)
U-234	2.3E+03	4.9E+03	2.3E+04	3.78E+03	3.61E+03 (96%)

APPENDIX D

MATERIAL BALANCE, EMISSION FACTOR, AND REMOVAL EFFICIENCY CALCULATION SHEETS

Metals Calculations: Mercury

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Mercury flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Mercury loading	ug/dscm	12.1596	11.5976	10.1201		From metals analysis
4. Mercury emissions	g/hr	7.050	6.822	5.866		#2*#3/1000000
5. Mercury emissions	lb/hr	.0155	.0150	.0129		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.06	635259.05	637660.98		(#6/35.314)*60
8. Mercury loading	ug/dscm	9.0043	9.6847	11.2115		From metals analysis
9. Mercury emissions	g/hr	5.728	6.152	7.149		#7*#8/1000000
10. Mercury emissions	lb/hr	.0126	.0136	.0158		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.564	13599.479		(#11/35.314)*60
13. Mercury loading	ug/dscm	6.1961	7.9234	14.1601		From metals analysis
14. Mercury emissions	g/hr	.07942743	.10571055	.19256998		#12*#13/1000000
15. Mercury emissions	lb/hr	.00017510	.00023305	.00042454		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Mercury loading	ug/dscm	7.23	9.4007	11.1198		From metals analysis
19. Mercury emissions	g/hr	.10072823	.14166696	.18645329		#17*#18/1000000
20. Mercury emissions	lb/hr	.00022206	.00031232	.00041105		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Mercury loading	ug/dscm	10.9941	11.14	15.0655		From metals analysis
24. Mercury emissions	g/hr	.17773120	.18576425	.25772525		#22*#23/1000000
25. Mercury emissions	lb/hr	.00039182	.00040953	.00056818		#24/453.6

Mercury mass balances						
Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Mercury in pulv. coal	ug/g	.13	.13	.13		From analysis
28. Mercury in pulv. coal	lb/hr	.0164112	.0164112	.0164112	.0164112	#26*#27/1000000
29. Furnace mercury emissions	lb/hr	.00787414	.01021674	.01798497	.01202528	(#2-#22+#12)*(#13)*(1/(1000000*453.6))
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Mercury in bottom ash	ug/g	0	0	0		From analysis
32. Mercury in bottom ash	lb/hr	.0000	.0000	.0000	.0000	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1176.6898	1176.6898	1176.6898		From Sheet 1, average
34. Mercury in hopper ash	ug/g	0	.0112	0		From analysis
35. Mercury in hopper ash	lb/hr	0	.00001320	0	.00000440	#33*#34/1000000
36. Total mercury out	lb/hr	.00787414	.01022994	.01798497		#29+#32+#35
37. Mercury in - Mercury out	lb/hr	.00853706	.00618126	-.0015738		#28-#36
38. Mercury out/mercury in		.480	.623	1.096	.733	#36/#28
					.32235490	STDS

ESP						
39. ESP inlet mercury emissions	lb/hr	.00787414	.01021674	.01798497	.01202528	(#2-#22+#12)*(#13)*(1/(1000000*45
40. ESP outlet mercury emissions	lb/hr	.01262861	.01356326	.01576088	.01398425	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Mercury in ESP part.	ug/g	.2623	.3922	.5103		From analysis
43. Mercury in ESP part.	lb/hr	.00302412	.00452177	.00588338	.00447642	#23*#25/1000000
44. Total mercury out	lb/hr	.01565273	.01808503	.02164426		#40+#43
45. Mercury in - Mercury out	lb/hr	-.0077786	-.0078683	-.0036593		#39-#44
46. Mercury out/mercury in		1.988	1.770	1.203		#44/#39
Boiler and ESP						
47. Mercury in pulv. coal	lb/hr	.0164112	.0164112	.0164112		#28
47a.Mercury exiting to SNRB system	lb/hr	.00017510	.00023305	.00042454		#51
47b Mercury entering from SNRB system	lb/hr	.00039182	.00040953	.00056818		#58
48. *Total mercury out (except #47a)*	lb/hr	.01565273	.01809823	.02164426		#32+#35+#43+#40
49. Mercury in - Mercury out	lb/hr	.00097519	-.0015105	-.0050894		#47+#47b-#48-#47a
50. Mercury out/mercury in		.942	1.090	1.300	1.111	(#48+#47a)/(#47+47b)
					.17978470	STDS
SNRB system						
51. SNRB system inlet mercury	lb/hr	.00017510	.00023305	.00042454	.00027756	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Mercury in Ca(OH)2	ug/g	0	0	0		From analysis
54. Mercury in Ca(OH)2	lb/hr	0	0	0	0	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From sheet 1, average
56. Mercury in baghouse discharge	ug/g	0	0	0		From analysis
57. Mercury in baghouse discharge	lb/hr	0	0	0	0	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	.00039182	.00040953	.00056818	.00045651	#25
59. Total mercury in	lb/hr	.00017510	.00023305	.00042454		#51+#54
60. Total mercury out	lb/hr	.00039182	.00040953	.00056818		#57+#58
61. Mercury in - Mercury out	lb/hr	-.0002167	-.0001765	-.0001436		#59-#60
62. Mercury out/mercury in		2.238	1.757	1.338		#60/#59
Mercury Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Mercury emissions	lb/hr	.00787414	.01021674	.01798497		(#2-#22+#12)*(#13)*(1/(1000000*453
67. Mercury emissions	lb/10*6 Btu	.0000049	.0000064	.0000113	.0000075	#66/#65
					.00000332	
ESP emissions						
68. Mercury emissions	lb/hr	.01262861	.01356326	.01576088		#10
69. Mercury emissions	lb/10*6 Btu	.00000793	.00000851	.00000989	.00000878	#68/#65
					.00000101	
SNRB emissions						
70. Mercury emissions	lb/hr	.00039182	.00040953	.00056818		#25
71. Mercury emissions	lb/10*6 Btu	.00001106	.00001127	.00001511	.00001248	(#70/#65)*((#1-#21+#11)/#11)
					.00000228	
Removal Efficiencies						
72. ESP	percent	-60.3808	-32.7553	12.3664		(#67-#69)*100/#67
73. SNRB	percent	-123.7655	-75.7291	-33.8346		(#51-#58)*100/#51

Metals Calculations: Chromium

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.094	588223.084	579632.214		(#1/35.314)*60
3. Metal loading	ug/dscm	195.80	570.88	422.16		From metals analysis
4. Metal emissions	g/hr	113.523292	335.804794	244.697535		#2*#3/1000000
5. Metal emissions	lb/hr	.250271808	.740310393	.539456648		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.060	635259.047	637660.984		(#6/35.314)*60
8. Metal loading	ug/dscm	.16	2.11	1.08		From metals analysis
9. Metal emissions	g/hr	.101788490	1.34039659	.688673863		#7*#8/1000000
10. Metal emissions	lb/hr	.000224401	.002955019	.001518240		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.9387	13341.5643	13599.4790		(#11/35.314)*60
13. Metal loading	ug/dscm	683.42	264.85	1402.91		From metals analysis
14. Metal emissions	g/hr	8.76071906	3.53351329	19.0788450		#12*#13/1000000
15. Metal emissions	lb/hr	.019313755	.007789932	.042060946		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.9817	15069.8307	16767.6842		(#16/35.314)*60
18. Metal loading	ug/dscm	388.62	1142.40	4933.84		From metals analysis
19. Metal emissions	g/hr	5.41424671	17.2157745	82.7290710		#17*#18/1000000
20. Metal emissions	lb/hr	.011936170	.037953648	.182383314		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.0531	16675.4262	17106.9831		(#21/35.314)*60
23. Metal loading	ug/dscm	.00	10.36	.05		From metals analysis
24. Metal emissions	g/hr	0	.172757415	.000855349		#22*#23/1000000
25. Metal emissions	lb/hr	0	.000380858	.000001886		#24/453.6

Chromium mass balances

Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240.0	126240.0	126240.0		From Sheet 1
27. Metal in pulv. coal	ug/g	14.00	16.00	14.00		From analysis
28. Metal in pulv. coal	lb/hr	1.76736	2.01984	1.76736	1.85152	#26*#27/1000000
29. Furnace metal emissions	lb/hr	.868505352	.341507739	1.78185872	.99729066	(#2-#22+#12)*(#13)*(1/(1000000*453.6)
30. Bottom ash	lb/hr	3529.71391	3529.71391	3529.71391		From Sheet 1, average
31. Metal in bottom ash	ug/g	102.3	115.4	111.5		From analysis
32. Metal in bottom ash	lb/hr	.361089733	.407328986	.393563101	.38732727	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.68980	1178.68980	1178.68980		From Sheet 1, average
34. Metal in hopper ash	ug/g	122.8	120.9	115.5		From analysis
35. Metal in hopper ash	lb/hr	.144743108	.142503597	.136138672	.14112846	#33*#34/1000000
36. Total metal out	lb/hr	1.37433819	.891340322	2.31156050		#29+#32+#35
37. Metal in - Metal out	lb/hr	.393021807	1.12849968	-.54420050		#28-#36
38. Metal out/metal in		.777622099	.441292539	1.30791717	.84227727	#36/#28
					.43691507	STDS

ESP						
39. ESP inlet metal emissions	lb/hr	.868505352	.341507739	1.78185872	.99729060	(#2-#22+#12)*(#13)*(1/(1000000*
40. ESP outlet metal emissions	lb/hr	.000224401	.002955019	.001518240	.00156589	#10
41. ESP hopper particulate	lb/hr	11529.2495	11529.2495	11529.2495		From Sheet 1, average
42. Metal in ESP part.	ug/g	124.5	124.3	122.3		From analysis
43. Metal in ESP part.	lb/hr	1.43539156	1.43308571	1.41002721	1.4261682	#23*#25/1000000
44. Total metal out	lb/hr	1.43561596	1.43604073	1.41154545		#40+#43
45. Metal in - Metal out	lb/hr	-.56711061	-1.0945330	.370313271		#39-#44
46. Metal out/metal in		1.65297307	4.20500201	.792175852		#44/#39
Boiler and ESP						
47. Metal in pulv. coal	lb/hr	1.76736	2.01984	1.76736		#28
47a.Metal exiting to SNRB system	lb/hr	.019313755	.007789932	.042060946		#51
47b Metal entering from SNRB system	lb/hr	0	.000380858	.000001886		#58
48. Total metal out (except #47a)	lb/hr	1.94144880	1.98587331	1.94124723		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	-.19340256	.026557614	-.21594629		#47+#47b-#48-#47a
50. Metal out/metal in		1.10943020	.986854104	1.12218566	1.0728233	(#48+#47a)/(#47+47b)
					.07472420	STDS
SNRB system						
51. SNRB system inlet metal	lb/hr	.019313755	.007789932	.042060946	.02305488	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	1.3	1.3	1.3		From analysis
54. Metal in Ca(OH)2	lb/hr	.000585	.0005733	.0005954	.00058457	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	31.4	31.9	34.8		From analysis
57. Metal in baghouse discharge	lb/hr	.0264702	.0268917	.0293364	.0275661	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	0	.000380858	.000001886	.00012758	#25
59. Total metal in	lb/hr	.019898755	.008363232	.042656346		#51+#54
60. Total metal out	lb/hr	.0264702	.027272558	.029338286		#57+#58
61. Metal in - Metal out	lb/hr	-.00657145	-.01890933	.013318060		#59-#60
62. Metal out/metal in		1.330	3.261	.688		#60/#59

Chromium Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.27504	1593.27504	1593.27504		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	.868505352	.341507739	1.78185872		(#2-#22+#12)*(#13)*(1/(1000000*
67. Metal emissions	lb/10*6 Btu	.000545107	.000214343	.001118362	.00062594	#66/#65
					.00045740	
ESP emissions						
68. Metal emissions	lb/hr	.000224401	.002955019	.001518240		#10
69. Metal emissions	lb/10*6 Btu	.000000141	.000001855	.000000953	.00000098	#68/#65
					.00000086	
SNRB emissions						
70. Metal emissions	lb/hr	0	.000380858	.000001886		#25
71. Metal emissions	lb/10*6 Btu	0	.000010479	.000000050	.00000351	(#70/#65)*((#1-#21+#11)/#11)
					.00000604	
Removal Efficiencies						
72. ESP	percent	99.9742	99.1347	99.9148		(#67-#69)*100/#67
73. SNRB	percent	100.0000	95.1109	99.9955		(#51-#58)*100/#51

Metals Calculations: Cadmium

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	.91	5.66	3.37		From metals analysis
4. Metal emissions	g/hr	.52761081	3.3293427	1.9533606		#2*#3/1000000
5. Metal emissions	lb/hr	.00116316	.00733982	.00430635		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.06	635259.05	637660.98		(#6/35.314)*60
8. Metal loading	ug/dscm	0	0	0		From metals analysis
9. Metal emissions	g/hr	0	0	0		#7*#8/1000000
10. Metal emissions	lb/hr	0	0	0		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.584	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	7.4	1.46	12.83		From metals analysis
14. Metal emissions	g/hr	.09486015	.01947868	.17448132		#12*#13/1000000
15. Metal emissions	lb/hr	.00020913	.00004294	.00038466		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	3.98	3.25	.00		From metals analysis
19. Metal emissions	g/hr	.05544929	.04897695	0		#17*#18/1000000
20. Metal emissions	lb/hr	.00012224	.00010797	0		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	.33	1.10	.18		From metals analysis
24. Metal emissions	g/hr	.00533480	.01834297	.00307926		#22*#23/1000000
25. Metal emissions	lb/hr	.00001176	.00004044	.00000679		#24/453.6

Cadmium mass balances						
Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126246	126246	126246		From Sheet 1
27. Metal in pulv. coal	ug/g	.00	.00	.00		From analysis
28. Metal in pulv. coal	lb/hr	0	0	0	0	#26*#27/1000000
29. Furnace metal emissions	lb/hr	.00940408	.00188258	.01629559	.00919409	(#2-#22+#12)*(#13)*(1/(1000000*453.6))
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	3.0	2.6	2.9		From analysis
32. Metal in bottom ash	lb/hr	.01058914	.00917726	.01023617	.01000086	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.6898	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	2.5	18.4	4.3		From analysis
35. Metal in hopper ash	lb/hr	.00294672	.02168789	.00506837	.00990099	#33*#34/1000000
36. Total metal out	lb/hr	.02293995	.03274773	.03160013		#29+#32+#35
37. Metal in - Metal out	lb/hr	-.0229400	-.0327477	-.0316001		#28-#36
38. Metal out/metal in						#36/#28

ESP						
39. ESP inlet metal emissions	lb/hr	.00940408	.00188258	.01629559	.00919409	(#2-#22+#12)*(#13)*(1/(1000000*45
40. ESP outlet metal emissions	lb/hr	0	0	0	0	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	1.3	1.5	.8		From analysis
43. Metal in ESP part.	lb/hr	.01498802	.01729387	.00922340	.01383510	#23+#25/1000000
44. Total metal out	lb/hr	.01498802	.01729387	.00922340		#40+#43
45. Metal in - Metal out	lb/hr	-.0055839	-.0154113	.00707219		#39-#44
46. Metal out/metal in		1.5937781	9.1862628	.56600584		#44/#39
Boiler and ESP						
47. Metal in pulv. coal	lb/hr	0	0	0		#28
47a. Metal exiting to SNRB system	*lb/hr*	*.00020913*	*.00004294*	*.00038466*		#51
47b Metal entering from SNRB system	lb/hr	.00001176	.00004044	.00000679		#58
48. Total metal out (except #47a)	lb/hr	.02852389	.04815902	.02452794		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	-.0287213	-.0481615	-.0249058		#47+#47b-#48-#47a
50. Metal out/metal in		2443.0725	1191.9778	3669.8312		(#48+#47a)/(#47+47b)
SNRB system						
51. SNRB system inlet metal	lb/hr	.00020913	.00004294	.00038466	.00021224	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	0	0	0		From analysis
54. Metal in Ca(OH)2	lb/hr	0	0	0	0	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	0	0	0		From analysis
57. Metal in baghouse discharge	lb/hr	0	0	0	0	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	.00001176	.00004044	.00000679	.00001966	#25
59. Total metal in	lb/hr	.00020913	.00004294	.00038466		#51+#54
60. Total metal out	*lb/hr*	*.00001176*	*.00004044*	*.00000679*		#57+#58
61. Metal in - Metal out	lb/hr	.00019737	.00000250	.00037787		#59-#60
62. Metal out/metal in		.05623855	.94169447	.01764806		#60/#59

Cadmium Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	.00940408	.00188258	.01629559		(#2-#22+#12)*(#13)*(1/(1000000*453
67. Metal emissions	lb/10*6 Btu	.00000590	.00000118	.00001023	.00000577 .00000452	#66/#65
ESP emissions						
68. Metal emissions	lb/hr	0	0	0		#10
69. Metal emissions	lb/10*6 Btu	0	0	0	0 0	#68/#65
SNRB emissions						
70. Metal emissions	lb/hr	.00001176	.00004044	.00000679		#25
71. Metal emissions	lb/10*6 Btu	.00000033	.00000111	.00000018	.00000054 .00000050	(#70/#65)*((#1-#21+#11)/#11)
Removal Efficiencies						
72. ESP	percent	100.0000	100.0000	100.0000		(#67-#69)*100/#67
73. SNRB	percent	94.3761	5.8306	98.2352		(#51-#58)*100/#51

Metals Calculations: Nickel

		M-1	M-2	M-3		
Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	69.83	313.08	162.95		From metals analysis
4. Metal emissions	g/hr	40.486882	184.16088	94.451069		#2*#3/1000000
5. Metal emissions	lb/hr	.08925679	.40599842	.20822546		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.06	635259.05	637660.98		(#6/35.314)*60
8. Metal loading	ug/dscm	.00	.23	.00		From metals analysis
9. Metal emissions	g/hr	0	.14610958	0		#7*#8/1000000
10. Metal emissions	lb/hr	0	.00032211	0		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.564	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	309.59	150.72	668.41		From metals analysis
14. Metal emissions	g/hr	3.9686152	2.0108406	9.0900277		#12*#13/1000000
15. Metal emissions	lb/hr	.00874915	.00443307	.02003974		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	180.40	793.26	285.58		From metals analysis
19. Metal emissions	g/hr	2.5133295	11.954294	4.7885153		#17*#18/1000000
20. Metal emissions	lb/hr	.00554085	.02635426	.01055669		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	2.49	88.77	.00		From metals analysis
24. Metal emissions	g/hr	.04025347	1.4802776	0		#22*#23/1000000
25. Metal emissions	lb/hr	.00008874	.00326340	0		#24/453.6

Nickel mass balances

Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Metal in pulv. fuel	ug/g	7	9	8		From analysis
28. Metal in pulv. fuel	lb/hr	.88368	1.13616	1.00992	1.00992	#26*#27/1000000
29. Furnace metal emissions	lb/hr	.39343386	.19434414	.84895837	.47891213	(#2-#22+#12)*(#13)*(1/(1000000*453.6))
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	42.1	75.3	45.4		From analysis
32. Metal in bottom ash	lb/hr	.14860096	.26578746	.16024901	.19154581	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.6898	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	50.9	59.2	48.3		From analysis
35. Metal in hopper ash	lb/hr	.05999531	.06977844	.05693072	.06223482	#33*#34/1000000
36. Total metal out	lb/hr	.60203013	.52991004	1.0661381		#29+#32+#35
37. Metal in - Metal out	lb/hr	.28164987	.60624996	-.0562181		#28-#36
38. Metal out/metal in		.68127618	.46640441	1.0556659	.73444883	#36/#28
					.29820760	STDS

ESP						
39. ESP inlet metal emissions	lb/hr	.39343386	.19434414	.84895837	.47891213	(#2-#22+#12)*(#13)*(1/(1000000*453
40. ESP outlet metal emissions	lb/hr	0	.00032211	0	.00010737	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	52.2	59.7	59.1		From analysis
43. Metal in ESP part.	lb/hr	.60182682	.68829619	.68137864	.65716722	#23*#25/1000000
44. Total metal out	lb/hr	.60182682	.68861831	.68137864		#40+#43
45. Metal in - Metal out	lb/hr	-.2083930	-.4942742	.16757973		#39-#44
46. Metal out/metal in		1.5296772	3.5432933	.80260548		#44/#39
Boiler and ESP						
47. Metal in pulv. fuel	lb/hr	.88368	1.13616	1.00992		#28
47a.Metal exiting to SNRB system	lb/hr	.00874915	.00443307	.02003974		#51
47b Metal entering from SNRB system	lb/hr	.00008874	.00326340	0		#58
48. Total metal out (except #47a)	lb/hr	.81042309	1.0241842	.89855837		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	.06459650	.11080613	.09132188		#47+#47b-#48-#47a
50. Metal out/metal in		.927	.903	.910	.913	(#48+#47a)/(#47+47b)
					.01245298	STDS
SNRB system						
51. SNRB system inlet metal	lb/hr	.00874915	.00443307	.02003974	.01107399	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	0	0	0		From analysis
54. Metal in Ca(OH)2	lb/hr	0	0	0	0	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	12.0	19.2	12.0		From analysis
57. Metal in baghouse discharge	lb/hr	.010116	.0161856	.010116	.0121392	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	.00008874	.00326340	0	.00111738	#25
59. Total metal in	lb/hr	.00874915	.00443307	.02003974		#51+#54
60. Total metal out	lb/hr	.01020474	.01944900	.010116		#57+#58
61. Metal in - Metal out	lb/hr	-.0014556	-.0150159	.00992374		#59-#60
62. Metal out/metal in		1.1663693	4.3872527	.50479688		#60/#59

Nickel Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	.39343386	.19434414	.84895837		(#2-#22+#12)*(#13)*(1/(1000000*453
67. Metal emissions	lb/10*6 Btu	.00024693	.00012198	.00053284	.00030058	#66/#65
					.00021062	
ESP emissions						
68. Metal emissions	lb/hr	0	.00032211	0		#10
69. Metal emissions	lb/10*6 Btu	0	.00000020	0	.00000007	#68/#65
					.00000012	
SNRB emissions						
70. Metal emissions	lb/hr	.00008874	.00326340	0		#25
71. Metal emissions	lb/10*6 Btu	.00000250	.00008979	0	.00003077	(#70/#65)*((#1-#21+#11)/#11)
					.00005113	
Removal Efficiencies						
72. ESP	percent	100	99.834257	100		(#67-#69)*100/#67
73. SNRB	percent	98.985705	26.385134	100		(#51-#58)*100/#51

Metals Calculations: Barium

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	332.95	859.24	860.49		From metals analysis
4. Metal emissions	g/hr	193.04178	505.42480	498.76772		#2*#3/1000000
5. Metal emissions	lb/hr	.42557711	1.1142522	1.0995761		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.06	635259.05	637660.98		(#6/35.314)*60
8. Metal loading	ug/dscm	0	3.41	0		From metals analysis
9. Metal emissions	g/hr	0	2.1662334	0		#7*#8/1000000
10. Metal emissions	lb/hr	0	.00477565	0		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.564	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	925.65	739.67	2964.73		From metals analysis
14. Metal emissions	g/hr	11.865851	9.8683548	40.318783		#12*#13/1000000
15. Metal emissions	lb/hr	.02615928	.02175563	.08888621		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	217.85	137.21	92.89		From metals analysis
19. Metal emissions	g/hr	3.0350822	2.0677315	1.5575502		#17*#18/1000000
20. Metal emissions	lb/hr	.00669110	.00455849	.00343375		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	.00	.30	.00		From metals analysis
24. Metal emissions	g/hr	0	.00500263	0		#22*#23/1000000
25. Metal emissions	lb/hr	0	.00001103	0		#24/453.6

Barium mass balances						
Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Metal in pulv. coal	ug/g	45	51	46		From analysis
28. Metal to furnace	lb/hr	5.6808	6.43824	5.80704	5.97536	#26*#27/1000000
29. Furnace metal emissions	lb/hr	1.1763366	.95375884	3.7655516	1.9652157	(#2-#22+#12)*(#13)*(1/(1000000*453.6))
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	182.8	212.1	147.4		From analysis
32. Metal in bottom ash	lb/hr	.64523170	.74865232	.52027983	.63805462	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.6898	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	171.1	219.6	178.3		From analysis
35. Metal in hopper ash	lb/hr	.20167383	.25884028	.21016039	.22355817	#33*#34/1000000
36. Total metal out	lb/hr	2.0232422	1.9612514	4.4959918		#29+#32+#35
37. Metal in - Metal out	lb/hr	3.6575578	4.4769886	1.3110482		#28-#36
38. Metal out/metal in		.35615444	.30462540	.77423126	.47833703	#36/#28
					.25754388	STDS

ESP						
39. ESP inlet metal emissions	lb/hr	1.1763366	.95375884	3.7655516	1.9652157	(#2-#22+#12)*(#13)*(1/(1000000*45
40. ESP outlet metal emissions	lb/hr	0	.00477565	0	.00159188	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	232.5	244.6	247.2		From analysis
43. Metal in ESP part.	lb/hr	2.6805505	2.8200544	2.8500305	2.7835451	#23*#25/1000000
44. Total metal out	lb/hr	2.6805505	2.8248301	2.8500305		#40+#43
45. Metal in - Metal out	lb/hr	-1.504214	-1.871071	.91552114		#39-#44
46. Metal out/metal in		2.2787274	2.9617865	.75686932		#44/#39
Boiler and ESP						
47. Metal to furnace	lb/hr	5.6808	6.43824	5.66764		#28
47a. Metal exiting to SNRB system	lb/hr	.02615928	.02175563	.08888621		#51
47b Metal entering from SNRB system	lb/hr	0	.00001103	0		#58
48. Total metal out (except #47a)	lb/hr	3.5274560	3.8323227	3.5804707		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	2.1271847	2.5841727	2.1376831		#47+#47b-#48-#47a
50. Metal out/metal in		.62554839	.59862194	.63188077	.61868370	(#48+#47a)/(#47+47b)
					.01766014	STDS
SNRB system						
51. SNRB system inlet metal	lb/hr	.02615928	.02175563	.08888621	.04560037	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	14.1	11.6	15.1		From analysis
54. Metal in Ca(OH)2	lb/hr	.006345	.0051156	.0069158	.00612547	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	8.1	9.0	8.2		From analysis
57. Metal in baghouse discharge	lb/hr	.0068283	.007587	.0069126	.0071093	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	0	.00001103	0	.00000368	#25
59. Total metal in	lb/hr	.03250428	.02687123	.09580201		#51+#54
60. Total metal out	lb/hr	.0068283	.00759803	.0069126		#57+#58
61. Metal in - Metal out	lb/hr	.02567598	.01927320	.08888941		#59-#60
62. Metal out/metal in		.21007386	.28275699	.07215506		#60/#59
Barium Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	1.1763366	.95375884	3.7655516		(#2-#22+#12)*(#13)*(1/(1000000*453
67. Metal emissions	lb/10*6 Btu	.00073831	.00059862	.00236340	.00123344	#66/#65
					.00098106	
ESP emissions						
68. Metal emissions	lb/hr	0	.00477565	0		#10
69. Metal emissions	lb/10*6 Btu	0	.00000300	0	.00000100	#68/#65
					.00000173	
SNRB emissions						
70. Metal emissions	lb/hr	0	.00001103	0		#25
71. Metal emissions	lb/10*6 Btu	0	.00000030	0	.00000010	(#70/#65)*((#1-#21+#11)/#11)
					.00000018	
Removal Efficiencies						
72. ESP	percent	100	99.499282	100		(#67-#69)*100/#67
73. SNRB	percent	100	99.949306	100		(#51-#58)*100/#51

Metals Calculations: Cobalt

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	22.67	96.68	81.82		From metals analysis
4. Metal emissions	g/hr	13.143887	56.869408	47.425508		#2*#3/1000000
5. Metal emissions	lb/hr	.02897682	.12537347	.10455359		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.06	635259.05	637660.98		(#6/35.314)*60
8. Metal loading	ug/dscm	.00	.00	.00		From metals analysis
9. Metal emissions	g/hr	0	0	0		#7*#8/1000000
10. Metal emissions	lb/hr	0	0	0		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.564	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	126.58	44.54	303.28		From metals analysis
14. Metal emissions	g/hr	1.6226213	.59423327	4.1244500		#12*#13/1000000
15. Metal emissions	lb/hr	.00357721	.00131004	.00909270		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	77.27	267.20	113.33		From metals analysis
19. Metal emissions	g/hr	1.0765242	4.0266588	1.9002817		#17*#18/1000000
20. Metal emissions	lb/hr	.00237329	.00887711	.00418933		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	.00	2.69	.00		From metals analysis
24. Metal emissions	g/hr	0	.04485690	0		#22*#23/1000000
25. Metal emissions	lb/hr	0	.00009889	0		#24/453.6

Cobalt mass balances						
Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Metal in pulv. coal	ug/g	2	3	2		From analysis
28. Metal to furnace	lb/hr	.25248	.37872	.25248	.29456	#26*#27/1000000
29. Furnace metal emissions	lb/hr	.16086068	.05743158	.38520084	.20116437	(#2-#22+#12)*(#13)*(1/(1000000*453.6))
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	7.8	24.7	16.5		From analysis
32. Metal in bottom ash	lb/hr	.02753177	.08718393	.05824028	.05765199	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.6898	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	13.4	22.6	11.1		From analysis
35. Metal in hopper ash	lb/hr	.01579444	.02663839	.01308346	.01850543	#33*#34/1000000
36. Total metal out	lb/hr	.20418689	.17125391	.45652458		#29+#32+#35
37. Metal in - Metal out	lb/hr	.04829311	.20746609	-.2040446		#28-#36
38. Metal out/metal in		.80872502	.45219134	1.8081614	1.0230259	#36/#28
					.70292768	STDS

ESP						
39. ESP inlet metal emissions	lb/hr	.16086068	.05743158	.38520084	.20116437	(#2-#22+#12)*(#13)*(1/(1000000*45
40. ESP outlet metal emissions	lb/hr	0	0	0	0	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	19.2	15.4	20.6		From analysis
43. Metal in ESP part.	lb/hr	.22136159	.17755044	.23750254	.21213819	#23*#25/1000000
44. Total metal out	lb/hr	.22136159	.17755044	.23750254		#40+#43
45. Metal in - Metal out	lb/hr	-.0605009	-.1201189	.14769830		#39-#44
46. Metal out/metal in		1.3761075	3.0915123	.61656807		#44/#39
Boiler and ESP						
47. Metal to furnace	lb/hr	.25248	.37872	.25248		#28
47a. Metal exiting to SNRB system	lb/hr	.00357721	.00131004	.00909270		#51
47b Metal entering from SNRB system	lb/hr	0	.00009889	0		#58
48. Total metal out (except #47a)	lb/hr	.26468780	.29137277	.30882628		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	-.0157850	.08613609	-.0654390		#47+#47b-#48-#47a
50. Metal out/metal in		1.062520	.772619	1.259185	1.031441	(#48+#47a)/(#47+47b)
					.24476701	STDS
SNRB system						
51. SNRB system inlet metal	lb/hr	.00357721	.00131004	.00909270	.00465998	#15
52. Ca(OH)2 injection	lb/hr	450	441	450		From process data
53. Metal in Ca(OH)2	ug/g	7.6	7.6	7.6		From analysis
54. Metal in Ca(OH)2	lb/hr	.00342	.0033516	.0034080	.00341747	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	6.7	9.7	8.9		From analysis
57. Metal in baghouse discharge	lb/hr	.0056481	.0081771	.0075027	.0071093	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	0	.00009889	0	.00003296	#25
59. Total metal in	lb/hr	.00699721	.00466164	.01257350		#51+#54
60. Total metal out	lb/hr	.0056481	.00827599	.0075027		#57+#58
61. Metal in - Metal out	lb/hr	.00134911	-.0036144	.00507080		#59-#60
62. Metal out/metal in		.80719346	1.7753396	.59670723		#60/#59

Cobalt Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	.16086068	.05743158	.38520084		(#2-#22+#12)*(#13)*(1/(1000000*453
67. Metal emissions	lb/10*6 Btu	.00010096	.00003605	.00024177	.00012626	#66/#65
					.00010517	
ESP emissions						
68. Metal emissions	lb/hr	0	0	0		#10
69. Metal emissions	lb/10*6 Btu	0	0	0	0	#68/#65
					0	
SNRB emissions						
70. Metal emissions	lb/hr	0	.00009889	0		#25
71. Metal emissions	lb/10*6 Btu	0	.00000272	0	.00000091	(#70/#65)*((#1-#21+#11)/#11)
					.00000157	
Removal Efficiencies						
72. ESP	percent	100	100	100		(#67-#69)*100/#67
73. SNRB	percent	100	92.451298	100		(#51-#58)*100/#51

Metals Calculations: Manganese

		M-1	M-2	M-3		Comments
Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	182.87	554.11	449.26		From metals analysis
4. Metal emissions	g/hr	106.02658	325.94029	260.40557		#2*#3/1000000
5. Metal emissions	lb/hr	.23374467	.71858326	.57408635		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.06	635259.05	637666.98		(#6/35.314)*60
8. Metal loading	ug/dscm	.55	31.70	2.73		From metals analysis
9. Metal emissions	g/hr	.34989793	20.137712	1.7408145		#7*#8/1000000
10. Metal emissions	lb/hr	.00077138	.04439531	.00383777		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.564	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	690.05	236.68	1,430.66		From metals analysis
14. Metal emissions	g/hr	8.8457086	3.1576814	19.456231		#12*#13/1000000
15. Metal emissions	lb/hr	.01950112	.00696138	.04289292		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	606.13	1,378.22	768.88		From metals analysis
19. Metal emissions	g/hr	8.4445920	20.769542	12.892337		#17*#18/1000000
20. Metal emissions	lb/hr	.01861683	.04578823	.02842226		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	.00	1.26	.23		From metals analysis
24. Metal emissions	g/hr	0	.02101104	.00393461		#22*#23/1000000
25. Metal emissions	lb/hr	0	.00004632	.00000867		#24/453.6
Manganese mass balances						
Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Metal in pulv. coal	ug/g	20	19	18		From analysis
28. Metal to furnace	lb/hr	2.5248	2.39856	2.27232	2.39856	#26*#27/1000000
29. Furnace metal emissions	lb/hr	.87693090	.30518426	1.8171044	.99973987	(#2-#22+#12)*(#13)*(1/(1000000*453.6))
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	149.3	139.1	143.3		From analysis
32. Metal in bottom ash	lb/hr	.52698829	.49098321	.50580800	.50792583	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.6898	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	151.0	147.7	134.0		From analysis
35. Metal in hopper ash	lb/hr	.17798216	.17409248	.15794443	.17000636	#33*#34/1000000
36. Total metal out	lb/hr	1.5818994	.97025995	2.4808569		#29+#32+#35
37. Metal in - Metal out	lb/hr	.94290065	1.4283000	-.2085369		#28-#36
38. Metal out/metal in		.62654442	.40451769	1.0917727	.70761159	#36/#28
					.35072606	STDS

ESP

39. ESP inlet metal emissions	lb/hr	.87693090	.30518426	1.8171044	.99973987	(#2-#22+#12)*(#13)*(1/(1000000*453
40. ESP outlet metal emissions	lb/hr	.00077138	.04439531	.00383777	.01633482	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	134.0	121.1	109.9		From analysis
43. Metal in ESP part.	lb/hr	1.5449194	1.3961921	1.2670645	1.4027254	#23+#25/1000000
44. Total metal out	lb/hr	1.5456908	1.4405874	1.2709023		#40+#43
45. Metal in - Metal out	lb/hr	-.6687599	-1.135403	.54620215		#39-#44
46. Metal out/metal in		1.7626141	4.7203857	.69941070		#44/#39

Boiler and ESP

47. Metal to furnace	lb/hr	2.5248	2.39856	2.27232		#26
47a.Metal exiting to SNRB system	lb/hr	.01950112	.00696138	.04289292		#51
47b Metal entering from SNRB system	lb/hr	0	.00004632	.00000867		#58
48. Total metal out (except #47a)	lb/hr	2.2506593	2.1056631	1.9346547		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	.25463962	.28598183	.29478102		#47+#47b-#48-#47a
50. Metal out/metal in		.89914464	.88077167	.87027360	.88339663	(#48+#47a)/(#47+47b)
					.01461342	STDS

SNRB system

51. SNRB system inlet metal	lb/hr	.01950112	.00696138	.04289292	.02311847	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	4.9	4.8	5.4		From analysis
54. Metal in Ca(OH)2	lb/hr	.002205	.0021168	.0024732	.002265	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	37.2	36.5	34.3		From analysis
57. Metal in baghouse discharge	lb/hr	.0313596	.0307695	.0289149	.030348	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	0	.00004632	.00000867	.00001833	#25
59. Total metal in	lb/hr	.02170612	.00907818	.04536612		#51+#54
60. Total metal out	lb/hr	.0313596	.03081582	.02892357		#57+#58
61. Metal in - Metal out	lb/hr	-.0096535	-.0217376	.01644255		#59-#60
62. Metal out/metal in		1.4447353	3.3944937	.63755885		#60/#59

Manganese Emission Factors

63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64

Boiler emissions

66. Metal emissions	lb/hr	.87693090	.30518426	1.8171044		(#2-#22+#12)*(#13)*(1/(1000000*453
67. Metal emissions	lb/10*6 Btu	.00055040	.00019155	.00114048	.00062747	#66/#65
					.00047914	

ESP emissions

68. Metal emissions	lb/hr	.00077138	.04439531	.00383777		#10
69. Metal emissions	lb/10*6 Btu	.00000048	.00002786	.00000241	.00001025	#68/#65
					.00001528	

SNRB emissions

70. Metal emissions	lb/hr	0	.00004632	.00000867		#25
71. Metal emissions	lb/10*6 Btu	0	.00000127	.00000023	.00000050	(#70/#65)*((#1-#21+#11)/#11)
					.00000068	

Removal Efficiencies

72. ESP	percent	99.912036	85.452950	99.788797		(#67-#69)*100/#67
73. SNRB	percent	100	99.334606	99.979777		(#51-#58)*100/#51

Metals Calculations: Vanadium

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	296.44	1,031.44	547.89		From metals analysis
4. Metal emissions	g/hr	171.87357	606.71682	317.57469		#2*#3/1000000
5. Metal emissions	lb/hr	.37890998	1.3375591	.70012058		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.1	635259.0	637661.0		(#6/35.314)*60
8. Metal loading	ug/dscm	.00	2.92	.36		From metals analysis
9. Metal emissions	g/hr	0	1.8549564	.22955795		#7*#8/1000000
10. Metal emissions	lb/hr	0	.00408941	.00050608		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.564	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	918.51	605.77	1,836.21		From metals analysis
14. Metal emissions	g/hr	11.774323	8.0819194	24.971499		#12*#13/1000000
15. Metal emissions	lb/hr	.02595750	.01781728	.05505181		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	525.29	2,855.18	826.43		From metals analysis
19. Metal emissions	g/hr	7.3183306	43.027079	13.857317		#17*#18/1000000
20. Metal emissions	lb/hr	.01613389	.09485688	.03054964		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	.00	.00	.00		From metals analysis
24. Metal emissions	g/hr	0	0	0		#22*#23/1000000
25. Metal emissions	lb/hr	0	0	0		#24/453.6
Vanadium mass balances						
Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Metal in pulv. coal	ug/g	20	27	20		From analysis
28. Metal to furnace	lb/hr	2.5248	3.40848	2.5248	2.81936	#26*#27/1000000
29. Furnace metal emissions	lb/hr	1.1672630	.78110305	2.3322001	1.4268554	(#2-#22+#12)*(#13)*(1/(1000000*453.6)
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	126.3	189.3	129.7		From analysis
32. Metal in bottom ash	lb/hr	.44580287	.66817484	.45780389	.52392720	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.6898	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	129.8	172.9	139.2		From analysis
35. Metal in hopper ash	lb/hr	.15299394	.20379547	.16407362	.17362101	#33*#34/1000000
36. Total metal out	lb/hr	1.7660598	1.6530734	2.9540776		#29+#32+#35
37. Metal in - Metal out	lb/hr	.75874024	1.7554066	-.4292776		#28-#36
38. Metal out/metal in		.69948501	.48498843	1.1700244	.78483261	#36/#28
					.35040224	STDS

ESP						
39. ESP inlet metal emissions	lb/hr	1.1672630	.78110305	2.3322001	1.4268554	(#2-#22+#12)*(#13)*(1/(1000000*4
40. ESP outlet metal emissions	lb/hr	0	.00408941	.00050608	.00153183	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	158.3	189.7	195.2		From analysis
43. Metal in ESP part.	lb/hr	1.8250802	2.1870986	2.2505095	2.0875628	#23*#25/1000000
44. Total metal out	lb/hr	1.8250802	2.1911880	2.2510156		#40+#43
45. Metal in - Metal out	lb/hr	-.6578172	-1.410085	.08118449		#39-#44
46. Metal out/metal in		1.5635553	2.8052483	.96518974		#44/#39
Boiler and ESP						
47. Metal to furnace	lb/hr	2.5248	3.40848	2.5248		#28
47a.Metal exiting to SNRB system	lb/hr	.02595750	.01781728	.05505181		#51
47b Metal entering from SNRB system	lb/hr	0	0	0		#58
48. Total metal out (except #47a)	lb/hr	2.4238770	3.0631583	2.8728931		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	.07496550	.32750437	-.4031449		#47+#47b-#48-#47a
50. Metal out/metal in		.97030834	.90391483	1.1596740	1.0112991	(#48+#47a)/(#47+47b)
					.13271536	STDS
SNRB system						
51. SNRB system inlet metal	lb/hr	.02595750	.01781728	.05505181	.03294220	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	3.8	3.0	3.3		From analysis
54. Metal in Ca(OH)2	lb/hr	.00171	.001323	.0015114	.0015148	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	53.4	74.3	53.3		From analysis
57. Metal in baghouse discharge	lb/hr	.0450162	.0626349	.0449319	.050861	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	0	0	0	0	#25
59. Total metal in	lb/hr	.02766750	.01914028	.05656321		#51+#54
60. Total metal out	lb/hr	.0450162	.0626349	.0449319		#57+#58
61. Metal in - Metal out	lb/hr	-.0173487	-.0434946	.01163131		#59-#60
62. Metal out/metal in		1.6270424	3.2724125	.79436622		#60/#59

Vanadium Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	1.1672630	.78110305	2.3322001		(#2-#22+#12)*(#13)*(1/(1000000*45
67. Metal emissions	lb/10*6 Btu	.00073262	.00049025	.00146378	.00089555	#66/#65
					.00050686	
ESP emissions						
68. Metal emissions	lb/hr	0	.00408941	.00050608		#10
69. Metal emissions	lb/10*6 Btu	0	.00000257	.00000032	.00000096	#68/#65
					.00000140	
SNRB emissions						
70. Metal emissions	lb/hr	0	0	0		#25
71. Metal emissions	lb/10*6 Btu	0	0	0	0	(#70/#65)*((#1-#21+#11)/#11)
					0	
Removal Efficiencies						
72. ESP	percent	100	99.476457	99.978306		(#67-#69)*100/#67
73. SNRB	percent	100	100	100		(#51-#58)*100/#51

Metals Calculations: Beryllium

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.1	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	9.97	32.62	23.30		From metals analysis
4. Metal emissions	g/hr	5.780527	19.187837	13.505431		#2*#3/1000000
5. Metal emissions	lb/hr	.0127437	.04230123	.02977388		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.1	635259.05	637660.98		(#6/35.314)*60
8. Metal loading	ug/dscm	.00	.00	.00		From metals analysis
9. Metal emissions	g/hr	0	0	0		#7*#8/1000000
10. Metal emissions	lb/hr	0	0	0		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.94	13341.564	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	36.90	17.49	81.00		From metals analysis
14. Metal emissions	g/hr	.4730188	.23334396	1.1015578		#12*#13/1000000
15. Metal emissions	lb/hr	.0010428	.00051443	.00242848		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.98	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	8.25	30.21	10.82		From metals analysis
19. Metal emissions	g/hr	.1149388	.45525958	.18142634		#17*#18/1000000
20. Metal emissions	lb/hr	.0002534	.00100366	.00039997		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.05	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	.00	.00	.00		From metals analysis
24. Metal emissions	g/hr	0	0	0		#22*#23/1000000
25. Metal emissions	lb/hr	0	0	0		#24/453.6

Beryllium mass balances

Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Metal in pulv. coal	ug/g	.7	.5	.8		From analysis
28. Metal to furnace	lb/hr	.088368	.06312	.100992	.08416	#26*#27/1000000
29. Furnace metal emissions	lb/hr	.0466933	.02255228	.10287941	.05744168	(#2-#22+#12)*(#13)*(1/(1000000*453.6))
30. Bottom ash	lb/hr	3529.714	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	4.8	5.4	4.9		From analysis
32. Metal in bottom ash	lb/hr	.0169426	.01906046	.01729560	.01776623	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.690	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	5.0	6.2	5.5		From analysis
35. Metal in hopper ash	lb/hr	.0058934	.00730788	.00648279	.00656137	#33*#34/1000000
36. Total metal out	lb/hr	.0697294	.04892061	.12665780		#29+#32+#35
37. Metal in - Metal out	lb/hr	.0186386	.01419939	-.0256658		#28-#36
38. Metal out/metal in		.7890800	.77504132	1.2541370	.93941943	#36/#28
					.27264379	STDS

ESP						
39. ESP inlet metal emissions	lb/hr	.0468933	.02255228	.10287941	.05744168	(#2-#22+#12)*(#13)*(1/(1000000*45
40. ESP outlet metal emissions	lb/hr	0	0	0	0	#10
41. ESP hopper particulate	lb/hr	11529.25	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	6.1	6.7	6.8		From analysis
43. Metal in ESP part.	lb/hr	.0703284	.07724597	.07839890	.07532443	#23*#25/1000000
44. Total metal out	lb/hr	.0703284	.07724597	.07839890		#40+#43
45. Metal in - Metal out	lb/hr	-.023435	-.0546937	.02448052		#39-#44
46. Metal out/metal in		1.499753	3.4251962	.76204650		#44/#39
Boiler and ESP						
47. Metal to furnace	lb/hr	.088368	.06312	.100992		#28
47a.Metal exiting to SNRB system	lb/hr	.0010428	.00051443	.00242848		#51
47b Metal entering from SNRB system	lb/hr	0	0	0		#58
48. Total metal out (except #47a)	lb/hr	.0931645	.10361430	.10217729		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	-.005839	-.0410087	-.0036138		#47+#47b-#48-#47a
50. Metal out/metal in		1.066079	1.6496947	1.0357827	1.2505190	(#48+#47a)/(#47+47b)
					.34602809	STDS
SNRB system						
51. SNRB system inlet metal	lb/hr	.0010428	.00051443	.00242848	.00132857	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	0	0	0		From analysis
54. Metal in Ca(OH)2	lb/hr	0	0	0	0	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	.0	1.1	1.1		From analysis
57. Metal in baghouse discharge	lb/hr	0	.0009273	.0009273	.0006182	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	0	0	0	0	#25
59. Total metal in	lb/hr	.0010428	.00051443	.00242848		#51+#54
60. Total metal out	lb/hr	0	.0009273	.0009273		#57+#58
61. Metal in - Metal out	lb/hr	.0010428	-.0004129	.00150118		#59-#60
62. Metal out/metal in		0	1.8025891	.38184404		#60/#59

Beryllium Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.275	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	.0468933	.02255228	.10287941		(#2-#22+#12)*(#13)*(1/(1 [illegible]000*453
67. Metal emissions	lb/10*6 Btu	.0000294	.00001415	.00006457	.00003605	#66/#65
					.00002585	
ESP emissions						
68. Metal emissions	lb/hr	0	0	0		#10
69. Metal emissions	lb/10*6 Btu	0	0	0	0	#68/#65
					0	
SNRB emissions						
70. Metal emissions	lb/hr	0	0	0		#25
71. Metal emissions	lb/10*6 Btu	0	0	0	0	(#70/#65)*((#1-#21+#11)/#11)
					0	
Removal Efficiencies						
72. ESP	percent	100	100	100		(#67-#69)*100/#67
73. SNRB	percent	100	100	100		(#51-#58)*100/#51

Metals Calculations: Arsenic

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	159.42	546.86	299.54		From metals analysis
4. Metal emissions	g/hr	92.430456	321.67568	173.62303		#2*#3/1000000
5. Metal emissions	lb/hr	.20377085	.70916154	.38276683		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.06	635259.05	637660.98		(#6/35.314)*60
8. Metal loading	ug/dscm	1.7828	6.3774	1.8384		From metals analysis
9. Metal emissions	g/hr	1.1341782	4.0513010	1.1722760		#7*#8/1000000
10. Metal emissions	lb/hr	.00250039	.00893144	.00258438		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.564	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	505.64	299.73	574.73		From metals analysis
14. Metal emissions	g/hr	6.4817681	3.9988671	7.8160285		#12*#13/1000000
15. Metal emissions	lb/hr	.01428961	.00881584	.01723110		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	263.86	565.76	455.16		From metals analysis
19. Metal emissions	g/hr	3.6760927	8.5259074	7.6319791		#17*#18/1000000
20. Metal emissions	lb/hr	.00810426	.01879609	.01682535		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	--------	2.1219	.2309		From metals analysis
24. Metal emissions	g/hr	--------	.03538359	.00395000		#22*#23/1000000
25. Metal emissions	lb/hr	--------	.00007801	.00000871		#24/453.6

Arsenic mass balances						
Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Metal in pulv. coal	ug/g	4	6	5		From analysis
28. Metal to furnace	lb/hr	.50496	.75744	.6312	.6312	#26*#27/1000000
29. Furnace metal emissions	lb/hr	.64257857	.38648335	.72997389	.58634527	(#2-#22+#12)*(#13)*(1/(1000000*453.6)
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	4.69	6.14	3.28		From analysis
32. Metal in bottom ash	lb/hr	.01655436	.02167244	.01157746	.01660142	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.6898	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	130.0	16.1	53.6		From analysis
35. Metal in hopper ash	lb/hr	.15322967	.01897691	.06317777	.07846145	#33*#34/1000000
36. Total metal out	lb/hr	.81236260	.42713270	.80472912		#29+#32+#35
37. Metal in - Metal out	lb/hr	-.3074026	.33030730	-.1735291		#28-#36
38. Metal out/metal in		1.6087662	.56391621	1.2749194	1.1492006	#36/#28
					.53364951	STDS

ESP						
39. ESP inlet metal emissions	lb/hr	.64257857	.38648335	.72997389	.58634527	(#2-#22+#12)*(#13)*(1/(1000000*4
40. ESP outlet metal emissions	lb/hr	.00250039	.00893144	.00258438	.00467207	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	159	203	219		From analysis
43. Metal in ESP part.	lb/hr	1.8331507	2.3404376	2.5249056	2.2328313	#23*#25/1000000
44. Total metal out	lb/hr	1.8356511	2.3493691	2.5274900		#40+#43
45. Metal in - Metal out	lb/hr	-1.193072	-1.962886	-1.797516		#39-#44
46. Metal out/metal in		2.8566951	6.0788365	3.4624390		#44/#39
Boiler and ESP						
47. Metal to furnace	lb/hr	.50496	.75744	.6312		#28
47a. Metal exiting to SNRB system	lb/hr	.01428961	.00881584	.01723110		#51
47b Metal entering from SNRB system	lb/hr	--------	.00007801	.00000871		#58
48. Total metal out (except #47a)	lb/hr	2.0054351	2.3900184	2.6022453		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	--------	-1.641316	-1.988268		#47+#47b-#48-#47a
50. Metal out/metal in		--------	3.1667027	4.1499370	3.6583198	(#48+#47a)/(#47+47b)
SNRB system						
51. SNRB system inlet metal	lb/hr	.01428961	.00881584	.01723110	.01344552	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	1.14	1.54	1.74		From analysis
54. Metal in Ca(OH)2	lb/hr	.000513	.00067914	.00079692	.00066302	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	60.4	80.6	84.7		From analysis
57. Metal in baghouse discharge	lb/hr	.0509172	.0679458	.0714021	.0634217	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	--------	.00007801	.00000871	.00004336	#25
59. Total metal in	lb/hr	.01480261	.00949498	.01802802		#51+#54
60. Total metal out	lb/hr	--------	.06802381	.07141081		#57+#58
61. Metal in - Metal out	lb/hr	--------	-.0585288	-.0533828		#59-#60
62. Metal out/metal in		--------	7.1641830	3.9611002		#60/#59
Arsenic Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	.64257857	.38648335	.72997389		(#2-#22+#12)*(#13)*(1/(1000000*45
67. Metal emissions	lb/10*6 Btu	.00040331	.00024257	.00045816	.00036801	#66/#65
					.00011204	
ESP emissions						
68. Metal emissions	lb/hr	.00250039	.00893144	.00258438		#10
69. Metal emissions	lb/10*6 Btu	.00000157	.00000561	.00000162	.00000293	#68/#65
					.00000232	
SNRB emissions						
70. Metal emissions	lb/hr	--------	.00007801	.00000871		#25
71. Metal emissions	lb/10*6 Btu	--------	.00000215	.00000023	.00000079	(#70/#65)*((#1-#21+#11)/#11)
					.00000135	
Removal Efficiencies						
72. ESP	percent	99.610881	97.689049	99.645962		(#67-#69)*100/#67
73. SNRB	percent	--------	99.115160	99.949463		(#51-#58)*100/#51

Metals Calculations: Lead

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	68.51	192.65	144.11		From metals analysis
4. Metal emissions	g/hr	39.721556	113.32118	83.530798		#2*#3/1000000
5. Metal emissions	lb/hr	.08756957	.24982623	.18415079		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.06	635259.05	637660.98		(#6/35.314)*60
8. Metal loading	ug/dscm	.0000	.1777	.0000		From metals analysis
9. Metal emissions	g/hr	0	.11288553	0		#7*#8/1000000
10. Metal emissions	lb/hr	0	.00024887	0		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.564	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	216.36	119.30	221.39		From metals analysis
14. Metal emissions	g/hr	2.7735056	1.5916486	3.0107886		#12*#13/1000000
15. Metal emissions	lb/hr	.00611443	.00350893	.00663754		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	27.342	47.590	47.608		From metals analysis
19. Metal emissions	g/hr	.38092824	.71717324	.79827591		#17*#18/1000000
20. Metal emissions	lb/hr	.00083979	.00158107	.00175987		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	---------	.9261	.0000		From metals analysis
24. Metal emissions	g/hr	---------	.01544311	0		#22*#23/1000000
25. Metal emissions	lb/hr	---------	.00003405	0		#24/453.6

Lead mass balances

Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Metal in pulv. coal	ug/g	5	5	6		From analysis
28. Metal to furnace	lb/hr	.6312	.6312	.75744	.67328	#26*#27/1000000
29. Furnace metal emissions	lb/hr	.27495511	.15382999	.28119103	.23665871	(#2-#22+#12)*(#13)*(1/(1000000*453.6)
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	6.56	5.69	6.16		From analysis
32. Metal in bottom ash	lb/hr	.02315492	.02008407	.02174304	.02166068	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.6898	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	6.15	5.21	4.34		From analysis
35. Metal in hopper ash	lb/hr	.00724894	.00614097	.00511551	.00616848	#33*#34/1000000
36. Total metal out	lb/hr	.30535897	.18005504	.30804958		#29+#32+#35
37. Metal in - Metal out	lb/hr	.32584103	.45114496	.44939042		#28-#36
38. Metal out/metal in		.48377530	.28525830	.40669832	.39191064	#36/#28
					.10008125	STDS

ESP						
39. ESP inlet metal emissions	lb/hr	.27495511	.15382999	.28119103	.23665871	(#2-#22+#12)*(#13)*(1/(1000000*4
40. ESP outlet metal emissions	lb/hr	0	.00024887	0	.00008296	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	31.60	33.20	34.20		From analysis
43. Metal in ESP part.	lb/hr	.36432428	.38277108	.39430033	.38046523	#23*#25/1000000
44. Total metal out	lb/hr	.36432428	.38301995	.39430033		#40+#43
45. Metal in - Metal out	lb/hr	-.0893692	-.2291900	-.1131093		#39-#44
46. Metal out/metal in		1.3250319	2.4898912	1.4022508		#44/#39
Boiler and ESP						
47. Metal to furnace	lb/hr	.6312	.6312	.75744		#26
47a.Metal exiting to SNRB system	lb/hr	.00611443	.00350893	.00663754		#51
47b Metal entering from SNRB system	lb/hr	---------	.00003405	0		#58
48. Total metal out (except #47a)	lb/hr	.39472815	.40924499	.42115888		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	---------	.21848013	.32964358		#47+#47b-#48-#47a
50. Metal out/metal in		---------	.65388412	.56479249	.60933831	(#48+#47a)/(#47+47b)
SNRB system						
51. SNRB system inlet metal	lb/hr	.00611443	.00350893	.00663754	.00542030	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	0	0	0		From analysis
54. Metal in Ca(OH)2	lb/hr	0	0	0	0	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	3.60	4.28	3.94		From analysis
57. Metal in baghouse discharge	lb/hr	.0030346	.00360804	.00332142	.00332142	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	---------	.00003405	0	.00001702	Average #25
59. Total metal in	lb/hr	.00611443	.00350893	.00663754		#51+#54
60. Total metal out	lb/hr	---------	.00364209	.00332142		#57+#58
61. Metal in - Metal out	lb/hr	---------	-.0001332	.00331612		#59-#60
62. Metal out/metal in		---------	1.0379490	.50039916		#60/#59

Lead Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	.27495511	.15382999	.28119103		(#2-#22+#12)*(#13)*(1/(1000000*45
67. Metal emissions	lb/10*6 Btu	.00017257	.00009655	.00017649	.00014854	#66/#65
					.00004506	
ESP emissions						
68. Metal emissions	lb/hr	0	.00024887	0		#10
69. Metal emissions	lb/10*6 Btu	0	.00000016	0	.00000005	#68/#65
					.00000009	
SNRB emissions						
70. Metal emissions	lb/hr	---------	.00003405	0		#25
71. Metal emissions	lb/10*6 Btu	---------	.00000094	0	.00000031	(#70/#65)*((#1-#21+#11)/#11)
					.00000066	
Removal Efficiencies						
72. ESP	percent	100	99.838220	100		(#67-#69)*100/#67
73. SNRB	percent	---------	99.029741	100		(#51-#58)*100/#51

Metals Calculations: Antimony

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	4.5274	15.4266	13.6614		From metals analysis
4. Metal emissions	g/hr	2.6249507	9.0742822	7.9185875		#2*#3/1000000
5. Metal emissions	lb/hr	.00578693	.02000503	.01745720		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.06	635259.05	637660.98		(#6/35.314)*60
8. Metal loading	ug/dscm	.0984	.0821	.0215		From metals analysis
9. Metal emissions	g/hr	.06259992	.05215477	.01370971		#7*#8/1000000
10. Metal emissions	lb/hr	.00013801	.00011498	.00003022		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.564	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	7.5561	8.9977	8.2743		From metals analysis
14. Metal emissions	g/hr	.09686118	.12004339	.11252617		#12*#13/1000000
15. Metal emissions	lb/hr	.00021354	.00026465	.00024807		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	8.0728	18.3205	13.2760		From metals analysis
19. Metal emissions	g/hr	.11247010	.27608683	.22260778		#17*#18/1000000
20. Metal emissions	lb/hr	.00024795	.00060866	.00049076		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	---------	1.4662	.0000		From metals analysis
24. Metal emissions	g/hr	---------	.02444951	0		#22*#23/1000000
25. Metal emissions	lb/hr	---------	.00005390	0		#24/453.6

Antimony mass balances

Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Metal in pulv. coal	ug/g	0	0	0		From analysis
28. Metal to furnace	lb/hr	0	0	0	0	#26*#27/1000000
29. Furnace metal emissions	lb/hr	.00960246	.01160198	.01050932	.01057125	(#2-#22+#12)*(#13)*(1/(1000000*453.6)
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	.31	.00	.00		From analysis
32. Metal in bottom ash	lb/hr	.00109421	0	0	.00036474	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.6898	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	.78	.00	.00		From analysis
35. Metal in hopper ash	lb/hr	.00091938	0	0	.00030646	#33*#34/1000000
36. Total metal out	lb/hr	.01161605	.01160198	.01050932		#29+#32+#35
37. Metal in - Metal out	lb/hr	-.0116160	-.0116020	-.0105093		#28-#36
38. Metal out/metal in						#36/#28

ESP						
39. ESP inlet metal emissions	lb/hr	.00960246	.01160198	.01050932	.01057125	(#2-#22+#12)*(#13)*(1/(1000000*4
40. ESP outlet metal emissions	lb/hr	.00013801	.00011498	.00003022	.00009440	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	1.26	1.43	1.48		From analysis
43. Metal in ESP part.	lb/hr	.01452685	.01648683	.01706329	.01602566	#23+#25/1000000
44. Total metal out	lb/hr	.01466486	.01660181	.01709351		#40+#43
45. Metal in - Metal out	lb/hr	-.0050624	-.0049998	-.0065842		#39-#44
46. Metal out/metal in		1.5271983	1.4309461	1.6265096		#44/#39
Boiler and ESP						
47. Metal to furnace	lb/hr	0	0	0		#28
47a.Metal exiting to SNRB system	lb/hr	.00021354	.00026465	.00024807		#51
47b Metal entering from SNRB system	lb/hr	---------	.00005390	0		#58
48. Total metal out (except #47a)	lb/hr	.01667845	.01660181	.01709351		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	---------	-.0168126	-.0173416		#47+#47b-#48-#47a
50. Metal out/metal in		---------	312.91516			(#48+#47a)/(#47+47b)
SNRB system						
51. SNRB system inlet metal	lb/hr	.00021354	.00026465	.00024807	.00024209	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	1.30	1.30	1.30		From analysis
54. Metal in Ca(OH)2	lb/hr	.000585	.0005733	.0005954	.00058457	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	.48	.69	.56		From analysis
57. Metal in baghouse discharge	lb/hr	.00040464	.00058167	.00047208	.00048613	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	---------	.00005390	0	.00002695	#25
59. Total metal in	lb/hr	.00079854	.00083795	.00084347		#51+#54
60. Total metal out	lb/hr	---------	.00063557	.00047208		#57+#58
61. Metal in - Metal out	lb/hr	---------	.00020237	.00037139		#59-#60
62. Metal out/metal in		---------	.75848693	.55968559		#60/#59

Antimony Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65 Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	.00960246	.01160198	.01050932		(#2-#22+#12)*(#13)*(1/(1000000*45
67. Metal emissions	lb/10*6 Btu	.00000603	.00000728	.00000660	.00000663 .00000663	#66/#65
ESP emissions						
68. Metal emissions	lb/hr	.00013801	.00011498	.00003022		#10
69. Metal emissions	lb/10*6 Btu	.00000009	.00000007	.00000002	.00000006 .00000004	#68/#65
SNRB emissions						
70. Metal emissions	lb/hr	---------	.00005390	0		#25
71. Metal emissions	lb/10*6 Btu	---------	.00000148	0	.00000049 .00000105	(#70/#65)*((#1-#21+#11)/#11)
Removal Efficiencies						
72. ESP	percent	98.562797	99.008965	99.712406		(#67-#69)*100/#67
73. SNRB	percent	---------	79.632773	100		(#51-#58)*100/#51

Metals Calculations: Selenium

Test		M-1	M-2	M-3		Comments
Date		4/27/93	4/29/93	4/30/93		
Metal flue gas loadings						
ESP Inlet (Location 10)						
1. Gas flow rate, dry	dscf/min	341246.3	346208.5	341152.2		From emissions calculations
2. Gas flow rate, dry	dscm/h	579792.09	588223.08	579632.21		(#1/35.314)*60
3. Metal loading	ug/dscm	84.1582	90.9122	193.0767		From metals analysis
4. Metal emissions	g/hr	48.794259	53.476655	111.91348		#2*#3/1000000
5. Metal emissions	lb/hr	.10757112	.11789386	.24672283		#4/453.6
ESP Outlet (Location 12)						
6. Gas flow rate, dry	dscf/min	374433.2	373892.3	375306		From emissions calculations
7. Gas flow rate, dry	dscm/h	636178.06	635259.05	637660.98		(#6/35.314)*60
8. Metal loading	ug/dscm	84.6055	6.3053	11.2978		From metals analysis
9. Metal emissions	g/hr	53.824163	4.0054989	7.2041663		#7*#8/1000000
10. Metal emissions	lb/hr	.11865997	.00883046	.01588220		#9/453.6
SNRB Inlet (Location 2)						
11. Gas flow rate, dry	dscf/min	7544.8	7852.4	8004.2		From emissions calculations
12. Gas flow rate, dry	dscm/h	12818.939	13341.564	13599.479		(#11/35.314)*60
13. Metal loading	ug/dscm	148.5547	89.5326	201.8141		From metals analysis
14. Metal emissions	g/hr	1.9043136	1.1945049	2.7445866		#12*#13/1000000
15. Metal emissions	lb/hr	.00419822	.00263339	.00605063		#14/453.6
SNRB Baghouse Inlet (Location 5)						
16. Gas flow rate, dry	dscf/min	8199.9	8869.6	9868.9		From emissions calculations
17. Gas flow rate, dry	dscm/h	13931.982	15069.831	16767.684		(#16/35.314)*60
18. Metal loading	ug/dscm	112.6046	154.1951	142.0555		From metals analysis
19. Metal emissions	g/hr	1.5688052	2.3236940	2.3819418		#17*#18/1000000
20. Metal emissions	lb/hr	.00345857	.00512278	.00525119		#19/453.6
SBRB Outlet (Location 7)						
21. Gas flow rate, dry	dscf/min	9514.8	9814.6	10068.6		From emissions calculations
22. Gas flow rate, dry	dscm/h	16166.053	16675.426	17106.983		(#21/35.314)*60
23. Metal loading	ug/dscm	---------	.0000	.0000		From metals analysis
24. Metal emissions	g/hr	---------	0	0		#22*#23/1000000
25. Metal emissions	lb/hr	---------	0	0		#24/453.6

Selenium mass balances						
Boiler Furnace						
26. Pulverized fuel fired	lb/hr	126240	126240	126240		From Sheet 1
27. Metal in pulv. coal	ug/g	3	3	2		From analysis
28. Metal to furnace	lb/hr	.37872	.37872	.25248	.33664	#26*#27/1000000
29. Furnace metal emissions	lb/hr	.18878662	.11544677	.25632736	.18685358	(#2-#22+#12)*(#13)*(1/(1000000*453.6)
30. Bottom ash	lb/hr	3529.7139	3529.7139	3529.7139		From Sheet 1, average
31. Metal in bottom ash	ug/g	.0	.0	.0		From analysis
32. Metal in bottom ash	lb/hr	0	0	0	0	#30*#31/1000000
33. Economizer hopper ash	lb/hr	1178.6898	1178.6898	1178.6898		From Sheet 1, average
34. Metal in hopper ash	ug/g	.0	.0	.0		From analysis
35. Metal in hopper ash	lb/hr	0	0	0	0	#33*#34/1000000
36. Total metal out	lb/hr	.18878662	.11544677	.25632736		#29+#32+#35
37. Metal in - Metal out	lb/hr	.18993338	.26327323	-.0038474		#28-#36
38. Metal out/metal in		.49848601	.30483409	1.0152383	.60618612	#36/#28
					.36724380	STDS

ESP						
39. ESP inlet metal emissions	lb/hr	.18878682	.11544677	.25832736	.186[illegible]358	(#2-#22+#12)*(#13)*(1/(1000000*45
40. ESP outlet metal emissions	lb/hr	.11865997	.00883046	.01588220	.04779088	#10
41. ESP hopper particulate	lb/hr	11529.249	11529.249	11529.249		From Sheet 1, average
42. Metal in ESP part.	ug/g	9.41	10.50	12.30		From analysis
43. Metal in ESP part.	lb/hr	.10849024	.12105712	.14180977	.12378571	#23*#25/1000000
44. Total metal out	lb/hr	.22715021	.12988758	.15769197		#40+#43
45. Metal in - Metal out	lb/hr	-.0383636	-.0144408	.09863539		#39-#44
46. Metal out/metal in		1.2032114	1.1250864	.61519758		#44/#39
Boiler and ESP						
47. Metal to furnace	lb/hr	.37872	.37872	.25248		#28
47a.Metal exiting to SNRB system	lb/hr	.00419822	.00263339	.00605063		#51
47b Metal entering from SNRB system	lb/hr	---------	0	0		#58
48. Total metal out (except #47a)	lb/hr	.22715021	.12988758	.15769197		#32+#35+#43+#40
49. Metal in - Metal out	lb/hr	---------	.24619903	.08873740		#47+#47b-#48-#47a
50. Metal out/metal in		---------	.34991807	.64853692	.49922750	(#48+#47a)/(#47+47b)
SNRB system						
51. SNRB system inlet metal	lb/hr	.00419822	.00263339	.00605063	.00429408	#15
52. Ca(OH)2 injection	lb/hr	450	441	458		From process data
53. Metal in Ca(OH)2	ug/g	.0	.0	.0		From analysis
54. Metal in Ca(OH)2	lb/hr	0	0	0	0	#52*#53/1000000
55. Baghouse discharge	lb/hr	843	843	843		From Sheet 1, average
56. Metal in baghouse discharge	ug/g	5.18	5.83	6.44		From analysis
57. Metal in baghouse discharge	lb/hr	.00436674	.00491469	.00542892	.00490345	#55*#56/1000000
58. SNRB system outlet emissions	lb/hr	---------	0	0	0	#25
59. Total metal in	lb/hr	.00419822	.00263339	.00605063		#51+#54
60. Total metal out	lb/hr	---------	.00491469	.00542892		#57+#58
61. Metal in - Metal out	lb/hr	---------	-.0022813	.00062171		#59-#60
62. Metal out/metal in		---------	1.8662990	.89724844		#60/#59

Selenium Emission Factors						
63. Coal firing rate	lb/hr	126240	126240	126240		From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621		From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.2750	1593.2750	1593.2750		#63*#64
Boiler emissions						
66. Metal emissions	lb/hr	.18878682	.11544677	.25832736		(#2-#22+#12)*(#13)*(1/(1000000*45
67. Metal emissions	lb/10*6 Btu	.00011849	.00007246	.00016088	.00011728	#66/#65
					.00004422	
ESP emissions						
68. Metal emissions	lb/hr	.11865997	.00883046	.01588220		#10
69. Metal emissions	lb/10*6 Btu	.00007448	.00000554	.00000997	.00003000	#68/#65
					.00003858	
SNRB emissions						
70. Metal emissions	lb/hr	---------	0	0		#25
71. Metal emissions	lb/10*6 Btu	---------	0	0	0	(#70/#65)*((#1-#21+#11)/#11)
					0	
Removal Efficiencies						
72. ESP	percent	37.145985	92.351050	93.803939		(#67-#69)*100/#67
73. SNRB	percent	---------	100	100		(#51-#58)*100/#51

APPENDIX E

<u>SUMMARY OF MATERIAL BALANCE RESULTS</u>

Metals Results: Mercury

		M-1	M-2	M-3	Average
Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Mercury mass balances					
Boiler Furnace					
Mercury in pulv. coal	lb/hr	.016411	.016411	.016411	.016411
Mercury in bottom ash	lb/hr	.000000	.000000	.000000	.000000
Mercury in hopper ash	lb/hr	.000000	.000013	.000000	.000004
Furnace mercury emissions	lb/hr	.007874	.010217	.017985	.012025
Total mercury out	lb/hr	.007874	.010230	.017985	.012030
Mercury in - Mercury out	lb/hr	.008537	.006181	-.001574	.004382
Mercury out/mercury in		.480	.623	1.096	.733
ESP					
ESP inlet mercury emissions	lb/hr	.007874	.010217	.017985	.012025
Mercury in ESP part.	lb/hr	.003024	.004522	.005883	.004476
ESP outlet mercury emissions	lb/hr	.012629	.013563	.015761	.013984
Total mercury out	lb/hr	.015653	.018085	.021644	.018461
Mercury in - Mercury out	lb/hr	-.007779	-.007868	-.003659	-.006435
Mercury out/mercury in		1.988	1.770	1.203	1.654
Boiler and ESP					
Mercury in pulv. coal	lb/hr	.016411	.016411	.016411	.016411
Mercury entering from SNRB system	lb/hr	.000392	.000410	.000568	.000457
Total mercury out (except to SNRB	lb/hr	.015653	.018098	.021644	.018465
Mercury exiting to SNRB system	lb/hr	.000175	.000233	.000425	.000278
Total mercury in	lb/hr	.016803	.016821	.016979	.016868
Total mercury out	lb/hr	.015828	.018331	.022069	.018743
Mercury in - Mercury out	lb/hr	.000975	-.001511	-.005089	-.001875
Mercury out/mercury in		.942	1.090	1.300	1.111
SNRB system					
SNRB system inlet mercury	lb/hr	.000175	.000233	.000425	.000278
Mercury in Ca(OH)2	lb/hr	0	0	0	0
Mercury in baghouse discharge	lb/hr	0	0	0	0
SNRB system outlet emissions	lb/hr	.000392	.000410	.000568	.000457
Total mercury in	lb/hr	.000175	.000233	.000425	.000278
Total mercury out	lb/hr	.000392	.000410	.000568	.000457
Mercury in - Mercury out	lb/hr	-.000217	-.000176	-.000144	-.000179
Mercury out/mercury in		2.238	1.757	1.338	1.778
Emission Factors					
Boiler emissions	lb/10*12 Btu	4.94	6.41	11.29	7.55
ESP emissions	lb/10*12 Btu	7.93	8.51	9.89	8.78
SNRB emissions	lb/10*12 Btu	11.06	11.27	15.11	12.48
Standard Deviations					
Boiler emissions					3.32
ESP emissions					1.01
SNRB emissions					2.28
95 percent confidence interval					
Boiler emissions					8.25
ESP emissions					2.51
SNRB emissions					5.66
Removal Efficiencies					
ESP	percent	-60.38	-32.76	12.37	-26.92
SNRB	percent	-123.77	-75.73	-33.83	-77.78
Standard Deviations					
ESP					36.72
SNRB					45.00
95 percent confidence interval					
ESP					91.23
SNRB					111.80

Metals Results: Chromium

Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Chromium mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	1.767360	2.019840	1.767360	1.851520
Metal in bottom ash	lb/hr	.361090	.407329	.393563	.387327
Metal in bottom ash	lb/hr	.144743	.142504	.136139	.141128
Furnace metal emissions	lb/hr	.868505	.341508	1.781859	.997291
Total metal out	lb/hr	1.374338	.891340	2.311560	1.525746
Metal in - Metal out	lb/hr	.393022	1.128500	-.544200	.325774
Metal out/metal in		.778	.441	1.308	.842
ESP					
ESP inlet metal emissions	lb/hr	.868505	.341508	1.781859	.997291
Metal in ESP part.	lb/hr	1.435392	1.433086	1.410027	1.426168
ESP outlet metal emissions	lb/hr	.000224	.002955	.001518	.001566
Total metal out	lb/hr	1.435616	1.436041	1.411545	1.427734
Metal in - Metal out	lb/hr	-.567111	-1.094533	.370313	-.430443
Metal out/metal in		1.653	4.205	.792	2.217
Boiler and ESP					
Metal in pulv. coal	lb/hr	1.767360	2.019840	1.767360	1.851520
Metal entering from SNRB system	lb/hr	0	.000381	.000002	.000128
Total metal out (except to SNRB)	lb/hr	1.941449	1.985873	1.941247	1.956190
Metal exiting to SNRB system	lb/hr	.019314	.007790	.042061	.023055
Total metal in	lb/hr	1.767360	2.020221	1.767362	1.851648
Total metal out	lb/hr	1.960763	1.993663	1.983308	1.979245
Metal in - Metal out	lb/hr	-.193403	.026558	-.215946	-.127597
Metal out/metal in		1.109	.987	1.122	1.073
SNRB system					
SNRB system inlet metal	lb/hr	.019314	.007790	.042061	.023055
Metal in Ca(OH)2	lb/hr	.000585	.000573	.000595	.000585
Metal in baghouse discharge	lb/hr	.026470	.026892	.029336	.027566
SNRB system outlet emissions	lb/hr	0	.000381	.000002	.000128
Total metal in	lb/hr	.019899	.008363	.042656	.023639
Total metal out	lb/hr	.026470	.027273	.029338	.027694
Metal in - Metal out	lb/hr	-.006571	-.018909	.013318	-.004054
Metal out/metal in		1.330	3.261	.688	1.760
Emission Factors					
Boiler emissions	lb/10*12 Btu	545.11	214.34	1118.36	625.94
ESP emissions	lb/10*12 Btu	.14	1.85	.95	.98
SNRB emissions	lb/10*12 Btu	0	10.48	0	3.51
Standard Deviations					
Boiler emissions					457.40
ESP emissions					.86
SNRB emissions					6.04
95 percent confidence interval					
Boiler emissions					1136.36
ESP emissions					2.13
SNRB emissions					15.00
Removal Efficiencies					
ESP	percent	99.97	99.13	99.91	99.67
SNRB	percent	100.00	95.11	100.00	98.37
Standard Deviations					
ESP					.47
SNRB					2.82
95 percent confidence interval					
ESP					1.16
SNRB					7.01

Metals Results: Cadmium

Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Cadmium mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	0	0	0	0
Metal in bottom ash	lb/hr	.010589	.009177	.010236	.010001
Metal in bottom ash	lb/hr	.002947	.021688	.005068	.009901
Furnace metal emissions	lb/hr	.009404	.001883	.016296	.009194
Total metal out	lb/hr	.022940	.032748	.031600	.029096
Metal in - Metal out	lb/hr	-.022940	-.032748	-.031600	-.029096
Metal out/metal in					
ESP					
ESP inlet metal emissions	lb/hr	.009404	.001883	.016296	.009194
Metal in ESP part.	lb/hr	.014988	.017294	.009223	.013835
ESP outlet metal emissions	lb/hr	0	0	0	0
Total metal out	lb/hr	.014988	.017294	.009223	.013835
Metal in - Metal out	lb/hr	-.005584	-.015411	.007072	-.004641
Metal out/metal in		1.594	9.186	.566	3.782
Boiler and ESP					
Metal in pulv. coal	lb/hr	0	0	0	0
Metal entering from SNRB system	lb/hr	.000012	.000040	.000007	.000020
Total metal out (except to SNRB)	lb/hr	.028524	.048159	.024528	.033737
Metal exiting to SNRB system	lb/hr	.000209	.000043	.000385	.000212
Total metal in	lb/hr	.000012	.000040	.000007	.000020
Total metal out	lb/hr	.028733	.048202	.024913	.033949
Metal in - Metal out	lb/hr	-.028721	-.048162	-.024906	-.033930
Metal out/metal in		2443.0725	1191.9778	3669.8312	2434.9605
SNRB system					
SNRB system inlet metal	lb/hr	.000209	.000043	.000385	.000212
Metal in Ca(OH)2	lb/hr	0	0	0	0
Metal in baghouse discharge	lb/hr	0	0	0	0
SNRB system outlet emissions	lb/hr	.000012	.000040	.000007	.000020
Total metal in	lb/hr	.000209	.000043	.000385	.000212
Total metal out	lb/hr	.000012	.000040	.000007	.000020
Metal in - Metal out	lb/hr	.000197	.000003	.000378	.000193
Metal out/metal in		.056	.942	.018	.339
Emission Factors					
Boiler emissions	lb/10*12 Btu	5.90	1.18	10.23	5.77
ESP emissions	lb/10*12 Btu	0	0	0	0
SNRB emissions	lb/10*12 Btu	.33	1.11	.18	.54
Standard Deviations					
Boiler emissions					4.52
ESP emissions					0
SNRB emissions					.50
95 percent confidence interval					
Boiler emissions					11.24
ESP emissions					0
SNRB emissions					1.24
Removal Efficiencies					
ESP	percent	100	100	100	100
SNRB	percent	94.38	5.83	98.24	66.15
Standard Deviations					
ESP					.00
SNRB					52.27
95 percent confidence interval					
ESP					2.496e-14
SNRB					129.86

Metals Results: Nickel

		M-1	M-2	M-3	Average
Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Nickel mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	.883680	1.136160	1.009920	1.009920
Metal in bottom ash	lb/hr	.148601	.265787	.160249	.191546
Metal in bottom ash	lb/hr	.059995	.069778	.056931	.062235
Furnace metal emissions	lb/hr	.393434	.194344	.848958	.478912
Total metal out	lb/hr	.602030	.529910	1.066138	.732693
Metal in - Metal out	lb/hr	.281650	.606250	-.056218	.277227
Metal out/metal in		.681	.466	1.056	.734
ESP					
ESP inlet metal emissions	lb/hr	.393434	.194344	.848958	.478912
Metal in ESP part.	lb/hr	.601827	.688296	.681379	.657167
ESP outlet metal emissions	lb/hr	0	.000322	0	.000107
Total metal out	lb/hr	.601827	.688618	.681379	.657275
Metal in - Metal out	lb/hr	-.208393	-.494274	.167580	-.178362
Metal out/metal in		1.530	3.543	.803	1.959
Boiler and ESP					
Metal in pulv. coal	lb/	.883680	1.136160	1.009920	1.009920
Metal entering from SNRB system	lb/	.000089	.003263	0	.001117
Total metal out (except to SNRB)	lb/hr	.810423	1.024184	.898558	.911055
Metal exiting to SNRB system	lb/hr	.008749	.004433	.020040	.011074
Total metal in	lb/hr	.883769	1.139423	1.009920	1.011037
Total metal out	lb/hr	.819172	1.028617	.918598	.922129
Metal in - Metal out	lb/hr	.064597	.110806	.091322	.088908
Metal out/metal in		.927	.903	.910	.913
SNRB system					
SNRB system inlet metal	lb/hr	.008749	.004433	.020040	.011074
Metal in Ca(OH)2	lb/hr	0	0	0	0
Metal in baghouse discharge	lb/hr	.010116	.016186	.010116	.012139
SNRB system outlet emissions	lb/hr	.000089	.003263	0	.001117
Total metal in	lb/hr	.008749	.004433	.020040	.011074
Total metal out	lb/hr	.010205	.019449	.010116	.013257
Metal in - Metal out	lb/hr	-.001456	-.015016	.009924	-.002183
Metal out/metal in		1.166	4.387	.505	2.019
Emission Factors					
Boiler emissions	lb/10*12 Btu	246.93	121.98	532.84	300.58
ESP emissions	lb/10*12 Btu	0	.20	0	.07
SNRB emissions	lb/10*12 Btu	2.50	89.79	0	30.77
Standard Deviations					
Boiler emissions					210.62
ESP emissions					.12
SNRB emissions					51.13
95 percent confidence interval					
Boiler emissions					523.26
ESP emissions					.29
SNRB emissions					127.04
Removal Efficiencies					
ESP	percent	100.00	99.83	100.00	99.94
SNRB	percent	98.99	26.39	100.00	75.12
Standard Deviations					
ESP					.10
SNRB					42.21
95 percent confidence interval					
ESP					.24
SNRB					104.87

Metals Results: Barium

Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Barium mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	5.680800	6.438240	5.807040	5.975360
Metal in bottom ash	lb/hr	.645232	.748652	.520286	.638055
Metal in bottom ash	lb/hr	.201674	.258840	.210160	.223558
Furnace metal emissions	lb/hr	1.176337	.953759	3.765552	1.965216
Total metal out	lb/hr	2.023242	1.961251	4.495992	2.826828
Metal in - Metal out	lb/hr	3.657558	4.476989	1.311048	3.148532
Metal out/metal in		.356	.305	.774	.478
ESP					
ESP inlet metal emissions	lb/hr	1.176337	.953759	3.765552	1.965216
Metal in ESP part.	lb/hr	2.680551	2.820054	2.850030	2.783545
ESP outlet metal emissions	lb/hr	.000000	.004776	.000000	.001592
Total metal out	lb/hr	2.680551	2.824830	2.850030	2.785137
Metal in - Metal out	lb/hr	-1.504214	-1.871071	.915521	-.819921
Metal out/metal in		2.279	2.962	.757	1.999
Boiler and ESP					
Metal in pulv. coal	lb/hr	5.680800	6.438240	5.807040	5.975360
Metal entering from SNRB system	lb/hr	0	.000011	0	.000004
Total metal out (except to SNRB)	lb/hr	3.527456	3.832323	3.580471	3.646750
Metal exiting to SNRB system	lb/hr	.026159	.021756	.088886	.045600
Total metal in	lb/hr	5.680800	6.438251	5.807040	5.975364
Total metal out	lb/hr	3.553615	3.854078	3.669357	3.692350
Metal in - Metal out	lb/hr	2.127185	2.584173	2.137683	2.283014
Metal out/metal in		.626	.599	.632	.619
SNRB system					
SNRB system inlet metal	lb/hr	.026159	.021756	.088886	.045600
Metal in Ca(OH)2	lb/hr	.006345	.005116	.006916	.006125
Metal in baghouse discharge	lb/hr	.006828	.007587	.006913	.007109
SNRB system outlet emissions	lb/hr	0	.000011	0	.000004
Total metal in	lb/hr	.032504	.026871	.095802	.051726
Total metal out	lb/hr	.006828	.007598	.006913	.007113
Metal in - Metal out	lb/hr	.025676	.019273	.088889	.044613
Metal out/metal in		.210	.283	.072	.188
Emission Factors					
Boiler emissions	lb/10*12 Btu	738.31	598.62	2363.40	1233.44
ESP emissions	lb/10*12 Btu	0	3.00	0	1.00
SNRB emissions	lb/10*12 Btu	0	.30	0	.10
Standard Deviations					
Boiler emissions					981.06
ESP emissions					1.73
SNRB emissions					.18
95 percent confidence interval					
Boiler emissions					2437.36
ESP emissions					4.30
SNRB emissions					.44
Removal Efficiencies					
ESP	percent	100.00	99.50	100.00	99.83
SNRB	percent	100.00	99.95	100.00	99.98
Standard Deviations					
ESP					.29
SNRB					.03
95 percent confidence interval					
ESP					.72
SNRB					.07

Metals Results: Cobalt

		M-1	M-2	M-3	Average
Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Cobalt mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	.252480	.378720	.252480	.294560
Metal in bottom ash	lb/hr	.027532	.087184	.058240	.057652
Metal in bottom ash	lb/hr	.015794	.026638	.013083	.018505
Furnace metal emissions	lb/hr	.160861	.057432	.385201	.201164
Total metal out	lb/hr	.204187	.171254	.456525	.277322
Metal in - Metal out	lb/hr	.048293	.207466	-.204045	.017238
Metal out/metal in		.809	.452	1.808	1.023
ESP					
ESP inlet metal emissions	lb/hr	.160861	.057432	.385201	.201164
Metal in ESP part.	lb/hr	.221362	.177550	.237503	.212138
ESP outlet metal emissions	lb/hr	0	0	0	0
Total metal out	lb/hr	.221362	.177550	.237503	.212138
Metal in - Metal out	lb/hr	-.060501	-.120119	.147698	-.010974
Metal out/metal in		1.376	3.092	.617	1.695
Boiler and ESP					
Metal in pulv. coal	lb/hr	.252480	.378720	.252480	.294560
Metal entering from SNRB system	lb/hr	0	.000099	0	.000033
Total metal out (except to SNRB)	lb/hr	.264688	.291373	.308826	.288296
Metal exiting to SNRB system	lb/hr	.003577	.001310	.009093	.004660
Total metal in	lb/hr	.252480	.378819	.252480	.294593
Total metal out	lb/hr	.268265	.292683	.317919	.292956
Metal in - Metal out	lb/hr	-.015785	.086136	-.065439	.001637
Metal out/metal in		1.063	.773	1.259	1.031
SNRB system					
SNRB system inlet metal	lb/hr	.003577	.001310	.009093	.004660
Metal in Ca(OH)2	lb/hr	.003420	.003352	.003481	.003417
Metal in baghouse discharge	lb/hr	.005648	.008177	.007503	.007109
SNRB system outlet emissions	lb/hr	0	.000099	0	.000033
Total metal in	lb/hr	.006997	.004662	.012574	.008077
Total metal out	lb/hr	.005648	.008276	.007503	.007142
Metal in - Metal out	lb/hr	.001349	-.003614	.005071	.000935
Metal out/metal in		.807	1.775	.597	1.060
Emission Factors					
Boiler emissions	lb/10*12 Btu	100.96	36.05	241.77	126.26
ESP emissions	lb/10*12 Btu	0	0	0	0
SNRB emissions	lb/10*12 Btu	0	2.72	0	.91
Standard Deviations					
Boiler emissions					105.17
ESP emissions					.00
SNRB emissions					1.57
95 percent confidence interval					
Boiler emissions					261.28
ESP emissions					.00
SNRB emissions					3.90
Removal Efficiencies					
ESP	percent	100.00	100.00	100.00	100.00
SNRB	percent	100.00	92.45	100.00	97.48
Standard Deviations					
ESP					.00
SNRB					4.36
95 percent confidence interval					
ESP					.00
SNRB					10.83

Metals Results: Manganese

		M-1	M-2	M-3	Average
Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Manganese mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	2.524800	2.398560	2.272320	2.398560
Metal in bottom ash	lb/hr	.526986	.490983	.505808	.507926
Metal in bottom ash	lb/hr	.177982	.174092	.157944	.170006
Furnace metal emissions	lb/hr	.876931	.305184	1.817104	.999740
Total metal out	lb/hr	1.581899	.970260	2.480857	1.677672
Metal in - Metal out	lb/hr	.942901	1.428300	-.208537	.720888
Metal out/metal in		.627	.405	1.092	.708
ESP					
ESP inlet metal emissions	lb/hr	.876931	.305184	1.817104	.999740
Metal in ESP part.	lb/hr	1.544919	1.396192	1.267065	1.402725
ESP outlet metal emissions	lb/hr	.000771	.044395	.003838	.016335
Total metal out	lb/hr	1.545691	1.440587	1.270902	1.419060
Metal in - Metal out	lb/hr	-.668760	-1.135403	.546202	-.419320
Metal out/metal in		1.763	4.720	.699	2.394
Boiler and ESP					
Metal in pulv. coal	lb/hr	2.524800	2.398560	2.272320	2.398560
Metal entering from SNRB system	lb/hr	0	.000046	.000009	.000018
Total metal out (except to SNRB)	lb/hr	2.250659	2.105663	1.934655	2.096992
Metal exiting to SNRB system	lb/hr	.019501	.006961	.042893	.023118
Total metal in	lb/hr	2.524800	2.398606	2.272329	2.398578
Total metal out	lb/hr	2.270160	2.112624	1.977548	2.120111
Metal in - Metal out	lb/hr	.254640	.285982	.294781	.278467
Metal out/metal in		.899	.881	.870	.883
SNRB system					
SNRB system inlet metal	lb/hr	.019501	.006961	.042893	.023118
Metal in Ca(OH)2	lb/hr	.002205	.002117	.002473	.002265
Metal in baghouse discharge	lb/hr	.031360	.030770	.028915	.030348
SNRB system outlet emissions	lb/hr	0	.000046	.000009	.000018
Total metal in	lb/hr	.021706	.009078	.045366	.025383
Total metal out	lb/hr	.031360	.030816	.028924	.030366
Metal in - Metal out	lb/hr	-.009653	-.021738	.016443	-.004983
Metal out/metal in		1.445	3.394	.638	1.826
Emission Factors					
Boiler emissions	lb/10*12 Btu	550.40	191.55	1,140.40	627.47
ESP emissions	lb/10*12 Btu	.48	27.86	2.41	10.25
SNRB emissions	lb/10*12 Btu	0	1.27	.23	.50
Standard Deviations					
Boiler emissions					479.14
ESP emissions					15.28
SNRB emissions					.68
95 percent confidence interval					
Boiler emissions					1,190.39
ESP emissions					37.97
SNRB emissions					1.69
Removal Efficiencies					
ESP	percent	99.91	85.45	99.79	95.05
SNRB	percent	100.00	99.33	99.98	99.77
Standard Deviations					
ESP					8.31
SNRB					.38
95 percent confidence interval					
ESP					20.65
SNRB					.94

Metals Results: Vanadium

Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Vanadium mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	2.524800	3.408480	2.524800	2.819360
Metal in bottom ash	lb/hr	.445803	.668175	.457804	.523927
Metal in bottom ash	lb/hr	.152994	.203795	.164074	.173621
Furnace metal emissions	lb/hr	1.167263	.781103	2.332200	1.426855
Total metal out	lb/hr	1.766060	1.653073	2.954078	2.124404
Metal in - Metal out	lb/hr	.758740	1.755407	-.429278	.694956
Metal out/metal in		.699	.485	1.170	.765
ESP					
ESP inlet metal emissions	lb/hr	1.167263	.781103	2.332200	1.426855
Metal in ESP part.	lb/hr	1.825080	2.187099	2.250509	2.087563
ESP outlet metal emissions	lb/hr	0	.004089	.000506	.001532
Total metal out	lb/hr	1.825080	2.191188	2.251016	2.089095
Metal in - Metal out	lb/hr	-.657817	-1.410085	.081184	-.662239
Metal out/metal in		1.564	2.805	.965	1.778
Boiler and ESP					
Metal in pulv. coal	lb/hr	2.524800	3.408480	2.524800	2.819360
Metal entering from SNRB system	lb/hr	0	0	0	0
Total metal out (except to SNRB)	lb/hr	2.423877	3.063158	2.872893	2.786643
Metal exiting to SNRB system	lb/hr	.025958	.017817	.055052	.032942
Total metal in	lb/hr	2.524800	3.408480	2.524800	2.819360
Total metal out	lb/hr	2.449834	3.080976	2.927945	2.819585
Metal in - Metal out	lb/hr	.074966	.327504	-.403145	-.000225
Metal out/metal in		.970	.904	1.160	1.011
SNRB system					
SNRB system inlet metal	lb/hr	.025958	.017817	.055052	.032942
Metal in Ca(OH)2	lb/hr	.001710	.001323	.001511	.001515
Metal in baghouse discharge	lb/hr	.045016	.062635	.044932	.050861
SNRB system outlet emissions	lb/hr	0	0	0	0
Total metal in	lb/hr	.027668	.019140	.056563	.034457
Total metal out	lb/hr	.045016	.062635	.044932	.050861
Metal in - Metal out	lb/hr	-.017349	-.043495	.011631	-.016404
Metal out/metal in		1.627	3.272	.794	1.898
Emission Factors					
Boiler emissions	lb/10*12 Btu	732.62	490.25	1,463.78	895.55
ESP emissions	lb/10*12 Btu	0	2.57	.32	.96
SNRB emissions	lb/10*12 Btu	0	0	0	0
Standard Deviations					
Boiler emissions					506.80
ESP emissions					1.40
SNRB emissions					.00
95 percent confidence interval					
Boiler emissions					1,259.11
ESP emissions					3.48
SNRB emissions					.00
Removal Efficiencies					
ESP	percent	100.00	99.48	99.98	99.82
SNRB	percent	100.00	100.00	100.00	100.00
Standard Deviations					
ESP					.30
SNRB					.00
95 percent confidence interval					
ESP					.74
SNRB					.00

Metals Results: Beryllium

		M-1	M-2	M-3	Average
Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Beryllium mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	.088368	.063120	.100992	.084160
Metal in bottom ash	lb/hr	.016943	.019060	.017296	.017766
Metal in bottom ash	lb/hr	.005893	.007308	.006483	.006561
Furnace metal emissions	lb/hr	.046893	.022552	.102879	.057442
Total metal out	lb/hr	.069729	.048921	.126658	.081769
Metal in - Metal out	lb/hr	.018639	.014199	-.025666	.002391
Metal out/metal in		.789	.775	1.254	.939
ESP					
ESP inlet metal emissions	lb/hr	.046893	.022552	.102879	.057442
Metal in ESP part.	lb/hr	.070328	.077246	.078399	.075324
ESP outlet metal emissions	lb/hr	0	0	0	0
Total metal out	lb/hr	.070328	.077246	.078399	.075324
Metal in - Metal out	lb/hr	-.023435	-.054694	.024481	-.017883
Metal out/metal in		1.500	3.425	.762	1.896
Boiler and ESP					
Metal in pulv. coal	lb/hr	.088368	.063120	.100992	.084160
Metal entering from SNRB system	lb/hr	0	0	0	0
Total metal out (except to SNRB)	lb/hr	.093164	.103614	.102177	.099652
Metal exiting to SNRB system	lb/hr	.001043	.000514	.002428	.001329
Total metal in	lb/hr	.088368	.063120	.100992	.084160
Total metal out	lb/hr	.094207	.104129	.104606	.100981
Metal in - Metal out	lb/hr	-.005839	-.041009	-.003614	-.016821
Metal out/metal in		1.066	1.650	1.036	1.251
SNRB system					
SNRB system inlet metal	lb/hr	.001043	.000514	.002428	.001329
Metal in Ca(OH)2	lb/hr	0	0	0	0
Metal in baghouse discharge	lb/hr	0	.000927	.000927	.000618
SNRB system outlet emissions	lb/hr	0	0	0	0
Total metal in	lb/hr	.001043	.000514	.002428	.001329
Total metal out	lb/hr	0	.000927	.000927	.000618
Metal in - Metal out	lb/hr	.001043	-.000413	.001501	.000710
Metal out/metal in		0	1.803	.382	.728
Emission Factors					
Boiler emissions	lb/10*12 Btu	29.43	14.15	64.57	36.05
ESP emissions	lb/10*12 Btu	0	0	0	0
SNRB emissions	lb/10*12 Btu	0	0	0	0
Standard Deviations					
Boiler emissions					25.85
ESP emissions					.00
SNRB emissions					.00
95 percent confidence interval					
Boiler emissions					64.23
ESP emissions					.00
SNRB emissions					.00
Removal Efficiencies					
ESP	percent	100.00	100.00	100.00	100.00
SNRB	percent	100.00	100.00	100.00	100.00
Standard Deviations					
ESP					.00
SNRB					.00
95 percent confidence interval					
ESP					.00
SNRB					.00

Metals Results: Arsenic

Test
Date

Arsenic mass balances

Boiler Furnace
Metal in pulv. coal
Metal in bottom ash
Metal in bottom ash
Furnace metal emissi

Total metal out
Metal in - Metal out
Metal out/metal in

ESP
ESP inlet metal emis

Metals Results: Lead

Test Date		M-1 4/27/93	M-2 4/29/93	M-3 4/30/93	Average 27,29,30
Lead mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	.631200	.631200	.757440	.673280
Metal in bottom ash	lb/hr	.023155	.020084	.021743	.021661
Metal in bottom ash	lb/hr	.007249	.006141	.005116	.006168
Furnace metal emissions	lb/hr	.274955	.153830	.281191	.236659
Total metal out	lb/hr	.305359	.180055	.308050	.264488
Metal in - Metal out	lb/hr	.325841	.451145	.449390	.408792
Metal out/metal in		.484	.285	.407	.392
ESP					
ESP inlet metal emissions	lb/hr	.274955	.153830	.281191	.236659
Metal in ESP part.	lb/hr	.364324	.382771	.394300	.380465
ESP outlet metal emissions	lb/hr	.000000	.000249	0	.000083
Total metal out	lb/hr	.364324	.383020	.394300	.380548
Metal in - Metal out	lb/hr	-.089369	-.229190	-.113109	-.143889
Metal out/metal in		1.325	2.490	1.402	1.739
Boiler and ESP					
Metal in pulv. coal	lb/hr	.631200	.631200	.757440	.673280
Metal entering from SNRB system	lb/hr	---------	.000034	0	.000017
Total metal out (except to SNRB)	lb/hr	.394728	.409245	.421159	.408377
Metal exiting to SNRB system	lb/hr	.006114	.003509	.006638	.005420
Total metal in	lb/hr	---------	.631234	.757440	.694337
Total metal out	lb/hr	.400843	.412754	.427796	.413798
Metal in - Metal out	lb/hr	---------	.218480	.329644	.274062
Metal out/metal in		---------	.654	.565	.609
SNRB system					
SNRB system inlet metal	lb/hr	.006114	.003509	.006638	.005420
Metal in Ca(OH)2	lb/hr	0	0	0	0
Metal in baghouse discharge	lb/hr	.003035	.003608	.003321	.003321
SNRB system outlet emissions	lb/hr	---------	.000034	0	.000017
Total metal in	lb/hr	.006114	.003509	.006638	.005420
Total metal out	lb/hr	---------	.003642	.003321	.003482
Metal in - Metal out	lb/hr	---------	-.000133	.003316	.001591
Metal out/metal in		---------	1.038	.500	.769
Emission Factors					
Boiler emissions	lb/10*12 Btu	172.57	96.55	176.49	148.54
ESP emissions	lb/10*12 Btu	.00	.16	0	.05
SNRB emissions	lb/10*12 Btu	---------	.94	0	.47
Standard Deviations					
Boiler emissions					45.06
ESP emissions					.09
SNRB emissions					---------
95 percent confidence interval					
Boiler emissions					111.96
ESP emissions					.22
SNRB emissions					---------
Removal Efficiencies					
ESP	percent	100.00	99.84	100.00	99.95
SNRB	percent	---------	99.03	100.00	66.34
Standard Deviations					
ESP					.09
SNRB					---------
95 percent confidence interval					
ESP					.23
SNRB					---------

Metals Results: Antimony

Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Antimony mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	0	0	0	0
Metal in bottom ash	lb/hr	.001094	0	0	.000365
Metal in bottom ash	lb/hr	.000919	0	0	.000306
Furnace metal emissions	lb/hr	.009602	.011602	.010509	.010571
Total metal out	lb/hr	.011616	.011602	.010509	.011242
Metal in - Metal out	lb/hr	-.011616	-.011602	-.010509	-.011242
Metal out/metal in					
ESP					
ESP inlet metal emissions	lb/hr	.009602	.011602	.010509	.010571
Metal in ESP part.	lb/hr	.014527	.016487	.017063	.016026
ESP outlet metal emissions	lb/hr	.000138	.000115	.000030	.000094
Total metal out	lb/hr	.014665	.016602	.017094	.016120
Metal in - Metal out	lb/hr	-.005062	-.005000	-.006584	-.005549
Metal out/metal in		1.527	1.431	1.627	1.528
Boiler and ESP					
Metal in pulv. coal	lb/hr	0	0	0	0
Metal entering from SNRB system	lb/hr	---------	.000054	0	.000027
Total metal out (except to SNRB)	lb/hr	.016678	.016602	.017094	.016791
Metal exiting to SNRB system	lb/hr	.000214	.000265	.000248	.000242
Total metal in	lb/hr	---------	.00005390	0	.00002695
Total metal out	lb/hr	.016892	.016866	.017342	.017033
Metal in - Metal out	lb/hr	---------	-.016813	-.017342	-.017077
Metal out/metal in		---------	312.91518		312.91518
SNRB system					
SNRB system inlet metal	lb/hr	.000214	.000265	.000248	.000242
Metal in Ca(OH)2	lb/hr	0	.000573	0	.000585
Metal in baghouse discharge	lb/hr	.000405	.000582	.000472	.000486
SNRB system outlet emissions	lb/hr	---------	.000054	0	.000027
Total metal in	lb/hr	.000799	.000838	.000843	.000827
Total metal out	lb/hr	---------	.000636	.000472	.000369
Metal in - Metal out	lb/hr	---------	.000202	.000371	.000191
Metal out/metal in		---------	.758	.560	.659
Emission Factors					
Boiler emissions	lb/10*12 Btu	6.03	7.28	6.60	6.63
ESP emissions	lb/10*12 Btu	.09	.07	.02	.06
SNRB emissions	lb/10*12 Btu	---------	1.48	0	.74
Standard Deviations					
Boiler emissions					.63
ESP emissions					.04
SNRB emissions					---------
95 percent confidence interval					
Boiler emissions					1.56
ESP emissions					.09
SNRB emissions					---------
Removal Efficiencies					
ESP	percent	98.56	99.01	99.71	99.09
SNRB	percent	---------	79.63	100.00	89.82
Standard Deviations					
ESP					.58
SNRB					---------
95 percent confidence interval					
ESP					1.44
SNRB					---------

Metals Results: Selenium

		M-1	M-2	M-3	Average
Test		M-1	M-2	M-3	Average
Date		4/27/93	4/29/93	4/30/93	27,29,30
Selenium mass balances					
Boiler Furnace					
Metal in pulv. coal	lb/hr	.378720	.378720	.252480	.336640
Metal in bottom ash	lb/hr	0	0	0	0
Metal in bottom ash	lb/hr	0	0	0	0
Furnace metal emissions	*lb/hr*	.188787	.115447	.256327	.186854
Total metal out	lb/hr	.188787	.115447	.256327	.186854
Metal in - Metal out	lb/hr	.189933	.263273	-.003847	.149786
Metal out/metal in		.498	.305	1.015	.606
ESP					
ESP inlet metal emissions	lb/hr	.188787	.115447	.256327	.186854
Metal in ESP part.	lb/hr	.108490	.121057	.141810	.123786
ESP outlet metal emissions	lb/hr	.118660	.008830	.015882	.047791
Total metal out	lb/hr	.227150	.129888	.157692	.171577
Metal in - Metal out	lb/hr	-.038364	-.014441	.098635	.015277
Metal out/metal in		1.203	1.125	.615	.981
Boiler and ESP					
Metal in pulv. coal	lb/hr	.378720	.378720	.252480	.336640
Metal entering from SNRB system	lb/hr	---------	0	0	0
Total metal out (except to SNRB)	lb/hr	.227150	.129888	.157692	.171577
Metal exiting to SNRB system	lb/hr	.004198	.002633	.006051	.004294
Total metal in	lb/hr	---------	.378720	.252480	.315600
Total metal out	lb/hr	.231348	.132521	.163743	.175871
Metal in - Metal out	lb/hr	---------	.246199	.088737	.167468
Metal out/metal in		---------	.350	.649	.499
SNRB system					
SNRB system inlet metal	lb/hr	.004198	.002633	.006051	.004294
Metal in Ca(OH)2	lb/hr	0	0	0	0
Metal in baghouse discharge	lb/hr	.004367	.004915	.005429	.004903
SNRB system outlet emissions	lb/hr	---------	0	0	0
Total metal in	lb/hr	.004198	.002633	.006051	.004294
Total metal out	lb/hr	---------	.004915	.005429	.003448
Metal in - Metal out	lb/hr	---------	-.002281	.000622	-.000553
Metal out/metal in		---------	1.866	.897	1.382
Emission Factors					
Boiler emissions	lb/10*12 Btu	118.49	72.46	160.88	117.28
ESP emissions	lb/10*12 Btu	74.48	5.54	9.97	30.00
SNRB emissions	lb/10*12 Btu	---------	0	0	0
Standard Deviations					
Boiler emissions					44.22
ESP emissions					38.58
SNRB emissions					---------
95 percent confidence interval					
Boiler emissions					109.87
ESP emissions					95.86
SNRB emissions					---------
Removal Efficiencies					
ESP	percent	37.15	92.35	93.80	74.43
SNRB	percent	---------	100.00	100.00	100.00
Standard Deviations					
ESP					32.30
SNRB					---------
95 percent confidence interval					
ESP					80.247080
SNRB					---------

Ash Mass Balances for Burger SNRB Tests

	Test		0-1	0-2	0-3	Average	Comments
	Date		4/26/93	5/01/93	5/02/93		
Coal Feed System							
1.	Coal feed	lb/hr	126240	126240	126240		Average for week
2.	Pyrite rejects	lb/hr	197	197	197		Average of two weighings
3.	Pulverized fuel fired	lb/hr	126043	126043	126043		By difference (#1-#2)
Boiler Furnace							
3.	Pulverized fuel fired	lb/hr	126043	126043	126043		By difference (#1-#2)
4.	Ash in pulv. fuel	percent	11.67	11.46	12.02		From analysis
5.	Ash to furnace	lb/hr	14709	14444	15150	14768	#3*#4/100
6.	Furnace particulate emissions	lb/hr	9205	9595	13848	10882	Emissions tests
7.	Comb. carbon in furnace part.	percent	5.61	7.66	8.66	7.31	Assume same as in ESP ash
8.	Ash in furnace part.	percent	94.39	92.34	91.34		100-#7
9.	Ash in furnace part.	lb/hr	8689	8860	12648	10066	#6*#8/100
10.	Bottom ash, as ash	lb/hr	4515	4188	1876		Assume 75% of #5-#9
11.	Comb. carbon in bottom ash	percent	.10	.04	.14		From analysis
12.	Ash in bottom ash	percent	99.90	99.96	99.86		100-#11
13.	Bottom ash, total material	lb/hr	4520	4190	1879	3530	#10/(#12/100)
14.	Economizer hopper ash, as ash	lb/hr	1505	1396	625		Assume 25% of #5-#9
15.	Comb. carbon in hopper ash	percent	.36	.24	.08		From analysis
16.	Ash in econ. hopper ash	percent	99.64	99.76	99.92		100-#14
17.	Econ. hopper ash, total material	lb/hr	1511	1399	626	1179	#14/(#16/100)
18.	Ash in - Ash out	lb/hr	.00	.00	.00	.00	#5-#9-#10-#14
19.	Ash out/ash in		1.00	1.00	1.00	1.00	(#9+#10+#14)/#5
ESP							
20.	ESP inlet particulate	lb/hr	12538	10136	12133		Emissions tests
21.	Comb. carbon in furnace part.	percent	5.61	7.66	8.66		Assume same as in ESP ash
22.	Ash in furnace part.	percent	94.39	92.34	91.34		100-#21
23.	Ash in furnace part.	lb/hr	11835	9359	11082		#20*#22/100
24.	ESP outlet emissions	lb/hr	76.19	89.52	53.53		Emissions tests
25.	Comb. carbon in ESP out. emis.	percent	5.61	7.66	8.66		Assume same as in ESP ash
26.	Ash in ESP outlet emisions	percent	94.39	92.34	91.34		100-#25
27.	Ash in ESP outlet emisions	lb/hr	71.92	82.66	48.89		#24*#26/100
28.	ESP hopper particulate	lb/hr	12462	10046	12079	11529	#20-#24
29.	Comb. carbon in ESP part.	percent	5.61	7.66	8.66		From analysis
30.	Ash in ESP part.	percent	94.39	92.34	91.34		100-#29
31.	Ash in ESP part.	lb/hr	11763	9277	11033		#28*#30/100
32.	Ash in - Ash out	lb/hr	.00	.00	.00	.00	#23-#27-#31
33.	Ash out/ash in		1.00	1.00	1.00	1.00	(#27+#31)/#23
Boiler and ESP							
34.	Ash to furnace	lb/hr	14,709.18	14,444.49	15,150.33		#5
35.	Bottom ash, as ash	lb/hr	4,515.48	4,188.42	1,876.41		#10
36.	Economizer hopper ash, as ash	lb/hr	1,505.16	1,396.14	625.47		#14
37.	Ash in SNRB inlet part.	lb/hr	197.15	201.39	285.71		#46
38.	Ash in SNRB outlet part.	lb/hr	1.39	1.01	.72		#56
39.	Ash in ESP part.	lb/hr	11,762.95	9,276.67	11,033.39		#31
40.	Ash in ESP outlet emisions	lb/hr	71.92	82.66	48.89		#27
41.	Ash in - Ash out	lb/hr	-3,342.08	-699.78	1,281.18	-920.23	#34+#38-#35-#36-#39-#40-#37
42.	Ash out/ash in		1.227	1.048	.915	1.064	(#35+#36+#39+#40+#37)/(#34+#38)
SNRB system							
43.	SNRB system inlet emissions	lb/hr	197.41	205.86	290.41		Emissions tests
44.	Comb. carbon in SNRB inlet part.	percent	.13	2.17	1.62		Ratio from baghouse discharge
45.	Ash in SNRB inlet part.	percent	99.87	97.83	98.38		100-#44
46.	Ash in SNRB inlet part.	lb/hr	197.15	201.39	285.71		#43*#45/100
47.	Ca(OH)2 injection	lb/hr	476	451	471		Average for two days
48.	SO2 reduction	lb/hr	148.34	140.78	150.12		From SRNB calculations
49.	Ca(OH)2 required to reduce SO2	lb/hr	171.54	162.80	173.59		From SRNB calculations
50.	Unreacted Ca(OH)2	lb/hr	304.46	288.20	297.41		#47-#49
51.	Reactant produced	lb/hr	367.61	348.89	372.02		#49*(120.1/56.06)
52.	Sum of reacted & unr. Ca(OH)2	lb/hr	672.08	637.09	669.43		#50+#51
53.	SNRB system outlet emissions	lb/hr	1.39	1.02	.72		Emissions tests
54.	Comb. carbon in SNRB outlet part.	percent	.03	.53	.49		Assume same as in baghouse discharge
55.	Ash in SNRB outlet part.	percent	99.97	99.47	99.51		100-#54
56.	Ash in SNRB outlet part.	lb/hr	1.39	1.01	.72		#53*#55/100
57.	Baghouse discharge	lb/hr	820	797	911		#43+#47+#48-#53
58.	Comb. carbon in baghouse disch.	percent	.03	.53	.49		From analysis
59.	Ash in baghouse discharge	percent	99.97	99.47	99.51		100-#58
60.	Ash in baghouse discharge	lb/hr	820	792	906		#57*#59/100
61.	Ash in - Ash out	lb/hr	.0	-.2	-.2	-.2	#46+#47+#48-#60-#56
62.	Ash out/ash in		1.000	1.000	1.000	1.000	(#56+#60)/(#46+#47+#48)

Particulate Emisisons: Organic Runs

Test		O-1	O-2	O-3	Comments
Date		4/26/93	5/01/93	5/02/93	
ESP inlet (Location 10)		HCl/Part	HCl/Part	HCl/Part	
1. Gas flow rate, dry	dscf/min	345185.5	331582.9	355629.6	From emissions calculations
2. Sample gas volume	dscf	57.8	64.2	58.0	From emissions calculations
3. Particulate mass	g	15.8721	14.8361	14.9596	From weighings
4. Particulate loading	mg/dscf	274.60	231.09	257.92	#3*1000/#2
5. Particulate emissions	lb/hr	12538.261	10135.730	12132.997	#4*#1*60/(1000*453.6)
ESP Outlet (Location 12)					
6. Gas flow rate, dry	dscf/min	377101.8	373826.0	376495.3	From emissions calculations
7. Sample gas volume	dscf	104.7	105.2	101.1	From emissions calculations
8. Particulate mass	g	.1583	.1877	.1063	From weighings
9. Particulate loading	mg/dscf	1.5119	1.7842	1.0514	#8*1000/#7
10. Particulate emissions	lb/hr	75.42	88.23	52.36	#9*#6*60/(1000*453.6)
SNRB Inlet (Location 2)					
11. Gas flow rate, dry	dscf/min	7351.0	7045.4	7414.2	From emissions calculations
12. Sample gas volume	dscf	80.6	82.4	72.8	From emissions calculations
13. Particulate mass	g	16.3655	18.1923	21.5660	From weighings
14. Particulate loading	mg/dscf	203.05	220.78	296.24	#13*1000/#12
15. Particulate emissions	lb/hr	197.43	205.75	290.52	#14*#11*60/(1000*453.6)
SNRB Baghouse Inlet (Location 6)					
16. Gas flow rate, dry	dscf/min				From emissions calculations
17. Sample gas volume	dscf	74.7	62.3	112.6	From emissions calculations
18. Particulate mass	g				
19. Particulate loading	mg/dscf				
20. Particulate emissions	lb/hr				
SBRB Outlet (Location 7)					
21. Gas flow rate, dry	dscf/min	9809.3	10078.0	9649.3	From emissions calculations
22. Sample gas volume	dscf	74.4	78.9	72.8	From emissions calculations
23. Particulate mass	g	.0717	.0538	.0338	From weighings
24. Particulate loading	mg/dscf	.9637	.6819	.4643	#23*1000/#22
25. Particulate emissions	lb/hr	1.250	.909	.593	#24*#21*60/(1000*453.6)
Ash Emission Factors					
63. Coal firing rate	lb/hr	126240	126240	126240	From Sheet 1
64. Coal heating value	Btu/lb	12621	12621	12621	From Sheet 1, average
65. Firing rate	10*6 Btuh	1593.3	1593.3	1593.3	#63*#64
Boiler emissions					
66. Ash emissions	lb/hr	9204.9	9594.9	13847.7	(#1-#21+#11)*60*#14*(1/453.6*1000)
67. Ash emissions	lb/10*6 Btu	5.7774	6.0221	8.6913	#66/#65
ESP emissions					
68. Ash emissions	lb/hr	75.417	88.226	52.362	#10
69. Ash emissions	lb/10*6 Btu	.0473	.0554	.0329	#68/#65
SNRB emissions					
70. Ash emissions	lb/hr	1.250	.909	.593	#25
71. Ash emissions	lb/10*6 Btu	.0366	.0266	.0177	(#70/#65)*((#1-#21+#11)/#11)
Removal Efficiencies					
72. ESP	percent	99.180687	99.080491	99.621868	(#67-#69)*100/#67
73. SNRB	percent	99.366650	99.558206	99.796024	(#15-#25)*100/#15

SNRB System Performance

Test Date		O-1 4/26/93	O-2 5/01/93	O-3 5/02/93	Average	Comments
SNRB Inlet						
1. Gas flow rate, dry	dscf/min	7351	7045.4	7414.2	7270.2	From emissions calculations
2. SO2 concentration	ppm	2299.4	2299.4	2299.4	2299.4	From SNRB data
3. SO2 flow	dscf/min	16.90	16.20	17.05	16.72	#1*#2/1,000,000
4. SO2 flow	lb/hr	168.48	161.48	169.93	166.63	#3*60*0.0749*(64.1/28.9)
SNRB Outlet						
5. Gas flow rate, dry	dscf/min	9809.3	10078.1	9649.3	9845.567	From emissions calculations
6. SO2 concentration	ppm	206.00	206.00	206.00	206.00	From SNRB data
7. SO2 flow	dscf/min	2.0207	2.0761	1.9878	2.0282	#5*#6/1,000,000
8. SO2 flow	lb/hr	20.14	20.69	19.81	20.22	#7*60*0.0749*(64.1/28.9)
SNRB Reactions						
9. SO2 reduction	lb/hr	148.34	140.78	150.12	146.41	#4-#8
10. Ca(OH)2 required to reduce SO2	lb/hr	171.54	162.80	173.59	169.31	#9*(74.10/64.08)
11. Ca(OH)2 injected	lb/hr	476	451	471	466	From SNRB data
12. Unreacted Ca(OH)2	lb/hr	304.46	288.20	297.41	296.69	#11-#10
13. Reactant produced	lb/hr	278.12	263.95	281.45	274.50	#10*(120.1/74.10)
14. Ca(OH)2 reacted	percent	36.04	36.10	36.86	36.33	(#10/#11)*100

APPENDIX F

FLUE GAS FLOW RATE, MOISTURE, AND
VELOCITY SUMMARIES AND
PROCESS DATA SHEETS

Sample Train	Test Date	Location 2 (dscfm)	Location 5 (dscfm)	Location 7 (dscfm)	Location 10 (dscfm)	Location 12 (dscfm)
SVOC - 1	26-Apr-93	7772	8529	9702	347963	379267
SVOC - 2	28-Apr-93	7692	8638	9190	343825	381823
SVOC - 3	1-May-93	7833	8691	10271	335529	375928
Metals - 1	27-Apr-93	7545	8200	9515	341246	374433
Metals - 2	29-Apr-93	7852	8870	9815	346208	373892
Metals - 3	30-Apr-93	8004	9869	10069	341152	375306
HCl/PART - 1	26-Apr-93	7351	---	9809	345185	377102
HCl/PART - 2	1-May-93	7045	---	10078	331583	373826
HCl/PART - 3	2-May-93	7414	---	9649	355630	376495
PART (L5 only) - 1	26-Apr-93	---	8342	---	---	---
PART (L5 only) - 2	1-May-93	---	8753	---	---	---
PART (L5 only) - 3	2-May-93	---	8770	---	---	---
Formaldehyde - 1	26-Apr-93	7544	8560	10248	338500	394206
Formaldehyde - 2	2-May-93	---	---	10183	342605	385900

Velocity Summaries

Sample Train	Test Date	Location 2 (ft/sec)	Location 5 (ft/sec)	Location 7 (ft/sec)	Location 10 (ft/sec)	Location 12 (ft/sec)
SVOC - 1	26-Apr-93	44.04	43.24	51.54	79.14	80.55
SVOC - 2	28-Apr-93	42.87	45.96	49.27	74.90	77.56
SVOC - 3	1-May-93	42.24	47.80	55.55	74.39	77.41
Metals - 1	27-Apr-93	41.55	45.63	51.57	77.44	77.04
Metals - 2	29-Apr-93	44.75	48.42	52.00	76.57	77.30
Metals - 3	30-Apr-93	45.18	54.11	55.76	75.08	77.78
HCl/PART - 1	26-Apr-93	41.43	---	55.02	73.97	79.42
HCl/PART - 2	1-May-93	39.40	---	55.46	76.36	78.91
HCl/PART - 3	2-May-93	41.52	---	53.20	76.63	77.50
PART (L5 only) - 1	26-Apr-93	---	46.80	---	---	---
PART (L5 only) - 2	1-May-93	---	48.36	---	---	---
PART (L5 only) - 3	2-May-93	---	48.09	---	---	---
Formaldehyde - 1	26-Apr-93	42.60	47.31	56.54	77.16	80.44
Formaldehyde - 2	2-May-93	---	---	52.96	76.25	75.43

Sample Train	Test Date	Location 2 (dscfm)	Location 5 (dscfm)	Location 7 (dscfm)	Location 10 (dscfm)	Location 12 (dscfm)
SVOC - 1	26-Apr-93	7.61%	7.61%	4.97%	8.00%	7.95%
SVOC - 2	28-Apr-93	9.58%	8.52%	8.06%	7.35%	7.26%
SVOC - 3	1-May-93	5.47%	8.55%	7.44%	7.93%	7.59%
Metals - 1	27-Apr-93	7.86%	9.38%	7.62%	7.52%	7.51%
Metals - 2	29-Apr-93	10.76%	9.02%	5.45%	8.13%	7.74%
Metals - 3	30-Apr-93	9.27%	8.28%	8.84%	8.48%	7.96%
HCl/PART - 1	26-Apr-93	7.83%	---	8.36%	2.10%	7.27%
HCl/PART - 2	1-May-93	8.77%	---	8.75%	11.03%	9.44%
HCl/PART - 3	2-May-93	8.84%	---	8.67%	5.54%	7.72%
PART (L5 only) - 1	26-Apr-93	---	7.99%	---	---	---
PART (L5 only) - 2	1-May-93	---	9.11%	---	---	---
PART (L5 only) - 3	2-May-93	---	8.61%	---	---	---
Formaldehyde - 1	26-Apr-93	7.20%	7.80%	6.70%	8.00%	4.19%
Formaldehyde - 2	2-May-93	---	---	3.22%	8.00%	1.78%

Moistures for the HCl trains at location 10 are biased low due to train backups
Formaldehyde Moistures at locations 2, 5, and 10 were calculated from other tests conducted on the same day.
Heavy particulate biased moistures at these locations

BOILER PROCESS DATA
(PROCESS DATA LOG NO. 1)

PROCESS DATA LOG NO. 1: POWER PLANT CONTROL ROOM
(Take data every one-half hour)

Date: 4-26-93

Time	Load, MW	Excess Oxygen, percent	Stack Opacity, percent West Burger	Steam temp., F SH Outlet	Steam temp., F RH Outlet	Steam Pres., psig	Steam Generation Rate, Klb/hr	Data Taker
0800	150	3.7	12.7	1051	1002	2017	1121.8	R. Vicker
0830	150	3.7	12.63	1049 / 1052	1005 / 995	2014	1126	R. Vicker
0900	150	3.4	13.69	1053 / 1051	1007 / 997	2015	1123.1	R. Vicker
0930	151	3.8	12.46	1050 / 1051	1005 / 995	2013	1121.9	R. Vicker
10:00	150	3.7	13.39	1051 / 1049	1005 / 995	2014	1119.3	R. Vicker
10:30	150	3.2	13.39	1050 / 1050	1004 / 994	2016	1116.3	R. Vicker
11:00	151	3.4	12.96	1050 / 1053	1006 / 996	2014	1124.	R. Vicker
11:30	151	3.5	13.18	1053 / 1053	1008 / 998	2019	1118.2	R. Vicker
12:00	151	2.9	12.60	1051 / 1050	1005 / 995	2012	1122.5	R. Vicker
12:35	151	4.2	10.55	1052 / 1047	1006 / 996	2013	1123.1	R. Vicker
13:05	151	3.3	12.67	1046 / 1049	1003 / 994	2016	1124.7	"
13:30	151	3.4	10.48	1052 / 1051	1006 / 996	2016	1122.7	"
14:00	151	3.3	11.75	1051 / 1050	1006 / 996	2014	1128.	"
14:35	151	4.0	9.17	1052 / 1051	1007 / 994	2015	1122.9	"
1500	152	3.7	9.837	1051 / 1050	1005 / 996	2015	1130.8	F. Ramsey
1530	152	3.	8.404	1051 / 1051	1006 / 997	2012	1133.2	"
1600	152	3.4	[illegible]	1049 / [illegible]	1006 / [illegible]	2015	1132	"
1630	152	2.[illegible]	8.[illegible]88	1051 / 1051	1005 / 996	[illegible]	1130.3	"
[illegible]	153	3.4	10.36	1050 / 1051	1005 / 996	2009.5	1129.[illegible]	"
[illegible]	152	3.4	9.118	1049 / 1050	1006 / 996	2009.3	[illegible]	"
[illegible]	152	3.2	12.1	[illegible]	[illegible]	2015	[illegible]	"
[illegible]	152	3.5	8.598	1049 / 1046	1002 / 992	[illegible]	1132.8	"
[illegible]	153	3.3	10.56	1048 / 1049	1005 / 995	2013.5	1124.5	"
[illegible]	153	3.6	9.641	1052 / 1054	1006 / 998	2022.9	1137.9	"
[illegible]	153	[illegible]	[illegible]	[illegible] / 1047	[illegible]	[illegible]	[illegible]	
[illegible]	152	3.	8.598	1044 / 1048	1002 / 993	2009.3	1135.2	"
[illegible]	153	3.6	9.51	1049 / 1050	1004 / 995	2015.4	1137.4	"
[illegible]	153	3.6	9.969	1055 / 1051	1006 / 997	2021.1	1129.1	"

PROCESS DATA LOG NO. 1: POWER PLANT CONTROL ROOM
(Take data every one-half hour)

Date: ____________________

Time	Load, MW	Excess Oxygen, percent	Stack Opacity, percent	Steam temp., F		Steam Pres., psig	Steam Generation Rate, lb/hr	Data Taker
				SH Outlet	RH Outlet			
2200	[illegible]	3.4	9.38	[illegible]	[illegible]	2016	1137	Ramsay
2230	152	3.2	8.6	1047/1048	1002/992	2011.	1132.5	"
2300	[illegible]	[illegible]	11.96	[illegible]	[illegible]	[illegible]	1130.7	H. Muller
2330	152	3.3	[illegible]	[illegible]	[illegible]	2015	[illegible]	"
2400	152	3.1	[illegible]	1047/[illegible]	1006/996	2015	1129.2	"
0030	152	3.1	13.44	1051/1051	1005/996	2017	1127.7	"
0100	[illegible]	[illegible]	11.96	[illegible]	[illegible]	[illegible]	[illegible]	"
0130	152	[illegible]	10.98	[illegible]	[illegible]	[illegible]	1130.[illegible]	"
0200	[illegible]	[illegible]	[illegible]	1054/1051	[illegible]/996	2007	1124.2	"
0230	152	3.6	11.08	1047/1046	1002/997	2016	1132	"
0300	[illegible]	[illegible]	[illegible]	1051/1050	1005/[illegible]	2012	[illegible]	"

PROCESS DATA LOG NO. 1: POWER PLANT CONTROL ROOM
(Take data every one-half hour)

Date: 4-27-93

Time	Load, MW net	Excess Oxygen, percent	Stack Opacity, percent	Steam temp., F SH Outlet	Steam temp., F RH Outlet	Steam Pres., psig	Steam Generation Rate, lb/hr	Data Taker
10:00	152	3.5	[illegible]	[illegible]	1005/996	2006	[illegible]	R. V[illegible]
10:30	152	4.3	9.00	1049/1052	1006/996	2009	1130	"
11:00	151	3.6	9.77	[illegible]/1047	[illegible]/991	[illegible]	1137	"
11:30	152	[illegible]	10.[illegible]	[illegible]/1054	1007/997	2013	1132	"
12:00	153	3.7	10.34	1052/1052	1007/997	2017	1139	"
12:30	152	3.9	9.44	1054/1051	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	3.2	9.5[illegible]	1054/1057	[illegible]	2007	1125	F[illegible]
[illegible]	152	3.7	9.17	[illegible]	[illegible]	2013	1137	F[illegible]
14:00	152	3.3	8.34	[illegible]	[illegible]	2013	1139	F[illegible]
14:30	152	[illegible]	[illegible]	1052/1044	1001/991	[illegible]	[illegible]	F[illegible]
15:00	153	3.21	7.06	1049/1051	1006/996	2019	1145	VElKovicH
1530	153	3.17	8.34	1051/1052	1006/996	2018	1141	"
1600	153	3.27	8.34	[illegible]/1048	1003/992	2016	1149	"
1630	153	3.36	6.42	[illegible]	1006/995	2015	[illegible]	[illegible]
1700	153	2.93	6.93	1051/1046	1002/992	2013	1152	VElKovich
1730	153	3.	6.679	1051/1051	1006/996	2013.5	1145	/
1800	153	3.3	6.049	1049/1051	1006/996	2016	1142.[illegible]	[illegible]
1830	153	3.9	6.3	1052/1049	1006/996	2017.[illegible]	1139.[illegible]	[illegible]
1900	153	3.4	6.49	1049/1052	1006/996	2014.9	1141.[illegible]	"
1930	153	3.2	6.62	1052/1054	1008/998	2012.3	1142.[illegible]	"
2000	153	3.2	6.23	1044/[illegible]	991/981	2017	1151	"
2030	153	3.62	6.55	1049/1049	1004/994	2015	1143	VElKovcH
2100	153	3.38	6.68	1054/1048	1005/995	2016	1142	"
2130	153	3.12	[illegible]	[illegible]	[illegible]	201[illegible]	[illegible]	
[illegible]	153	3.10	6.05	1051/1047	1003/993	2014	1137	"
2230	153	3.99	6.42	1052/1055	1007/997	2016	1135	"
2300	152	[illegible]	7.[illegible]	[illegible]	[illegible]	2016	[illegible]	H. M[illegible]
2330	152	3.21	10.07	1051/1051	1006/996	2019	1134	Budrevich

PROCESS DATA LOG NO. 1: POWER PLANT CONTROL ROOM
(Take data every one-half hour)

Date: 7-22-93

Time	Load, MW Net	Excess Oxygen, percent	Stack Opacity, percent	Steam temp., F SH Outlet	Steam temp., F RH Outlet	Steam Pres., psig	Steam Generation Rate, lb/hr	Data Taker
0000	152	3.61	6.52	1050 / 1051	1005 / 994	2020	1132	Bodeeuich
0030	161	4.32	6.48	1050 / 1046	1002 / 993	2017	1136	[illegible]
01:00								

PROCESS DATA LOG NO. 1: POWER PLANT CONTROL ROOM
(Take data every one-half hour)

Date: 4-28-93

Time	Load, MW net	Excess Oxygen, percent	Stack Opacity, percent Nert	Steam temp., F		Steam Pres., psig throttle	Steam Generation Rate, Klb/hr flow	Data Taker
				SH Outlet	RH Outlet			
0840	151	3.2	7.601	1046 / 1028	990 / 980	2017	1142	Wallner
0900	151	4.2	9.173	1051 / 1037	996 / 987	2014	1055	Wallner
0930	151	3.8	8.076	1054 / 1041	1000 / 991	2012	1128	Wallner
1030	151	3.8	7.601	1049 / 1053	1007 / 998	2011	1132	Wallner
1100	151	3.7	8.07	1035 / [illegible]	1007 / 997	2015	1127	[illegible]
1130	152	3.6	8.964	1051 / 1039	1002 / 992	2018	1138	Wallner
1200	154	4.	9.446	1042 / 1023	982 / 973	2051	1171	Wallner
1315	148	4.6	8.759	1008 / 1005	968 / 959	2018	1147	Wallner
1330	150	4.2	8.896	1025 / 999	970 / 961	2024	1161	Wallner
1400	150	4.2	7.804	1028 / 1005	974 / 965	2025	1157	Wallner
1430	151	3.2	7.619	[illegible] / 1001	971 / 962	2015	[illegible]	[illegible]
15:00	151	3.9	8.008	1026 / 1005	977 / 968	2024	1161	S[illegible]
15:30	150	4.3	8.212	1020 / 1000	969 / 959	2012	1161	"
16:00	142	3.2	9.555	1066 / 1059	998 / 987	1976	1049	"
[illegible]	[illegible]	[illegible]	9.1[illegible]	[illegible]	994 / [illegible]	2021	[illegible]	"

PROCESS DATA LOG NO. 1: POWER PLANT CONTROL ROOM
(Take data every one-half hour)

Date: 4/29/93

Time	Load, MW	Excess Oxygen, percent	Stack Opacity, percent	Steam temp., F		Steam Pres., psig	Steam Generation Rate, Klb/hr	Data Taker
				SH Outlet	RH Outlet			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1140	
[illegible]	[illegible]	[illegible]	6.0/9[illegible]	103[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	3.	6.5/[illegible]	1033	991	200[illegible]	1141	
[illegible]	[illegible]	2.5	[illegible]/10.	[illegible]	9[illegible]	[illegible]	1102	[illegible]
1100	151	2.87	7./10	1027	981	2005	1130	
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]		
1230	153	3.9	6.3/9.0	1033	988	2000	1149	
1300	153	3.8	6.[illegible]/10.1	103[illegible]	1000	1990	1151	
1400	153	3.2	6/10	1025	993	2014	1166	
[illegible]	[illegible]	2.97	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	
[illegible]	[illegible]	[illegible]	7.2/13.2	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]/16	[illegible]	[illegible]		[illegible]	
1700	145	4.1	6.45/5	1045	990	1975	1074	
[illegible]	154	[illegible]	[illegible]/10.	[illegible]	[illegible]	[illegible]		
1830	152	3.2	6.25/6	1046	1001	1997	1132	
1900	151	2.6	6.45/6	1039	990	200[illegible]	1139	
9:30	154	[illegible]	6.19/9.2	[illegible]	[illegible]	[illegible]	[illegible]	
20:00	151	[illegible]	9.45/6.2	1050	[illegible]	2003	11[illegible]	
20:30	151	3.00	[illegible]/6.2	1050	99[illegible]	2003	1128	
21:00	152	3.[illegible]	9.3[illegible]/[illegible]	1050	99[illegible]	2002	112[illegible]	
21:30	151	3.3	9.[illegible]/6.2	1048	9[illegible]	200[illegible]	1123	
2200	151	3.6	9.7[illegible]/7	1044	995	2005	1128	

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/28/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
0735	811		[illegible] 268-33[illegible]	[illegible]	[illegible] 31-49/33-52	[illegible]	[illegible]
	821		[illegible]	[illegible]	48/49	[illegible]	
0735	831		31		38		[illegible]
	841		400		59		
	851		260		5		
	861		N/A		[illegible]		
	862		[illegible]		57		
	871		N/A		[illegible]		
	872		420		[illegible]		
	881		290		48		
	882		360		52		
[illegible]	811		[illegible]	[illegible] 23-25	[illegible]	[illegible]	[illegible]
	821		[illegible]	[illegible]	[illegible] 50	[illegible]	
	831		170		[illegible]		
	841		360		[illegible]		
	851		[illegible]				
	861		N/A		[illegible]		
	862		[illegible]		[illegible]		
	871		[illegible]		[illegible]		
	872		[illegible]		[illegible]		
	881		[illegible]		[illegible]		
	882		[illegible]		[illegible]		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 1: POWER PLANT CONTROL ROOM
(Take data every one-half hour)

Date: [illegible]

Time	Load, MW	Excess Oxygen, percent	Stack Opacity, percent	Steam temp., F		Steam Pres., psig	Steam Generation Rate, Klb/hr	Data Taker
				SH Outlet	RH Outlet			
0845	151	3.47	6.[illegible]	1049 / 1042	1001 / 990	[illegible]	1120.9	R. [illegible]
0900	151	3.30	6.457	1053 / 1052	1009 / 992	2012	1121.2	R. [illegible]
[illegible]	[illegible]	3.49	6.1[illegible]	[illegible]	1006 / 990	[illegible]	1121.8	R. [illegible]
1030	152	2.[illegible]	[illegible].192	1050 / 1039	100[illegible] / 992	2008	1134.3	R. [illegible]
11:00	151	3.7[illegible]	[illegible]	105[illegible] / [illegible]	1005 / [illegible]	[illegible]	1136.[illegible]	[illegible]
1130	[illegible]	[illegible]	6.059	10[illegible] / 103[illegible]	[illegible]	2[illegible]	[illegible]	[illegible]
12:00	153	3.45	6.767	[illegible]	[illegible] / 1001	[illegible]	1135.5	[illegible]
12[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]36	R. [illegible]
[illegible]	--	3.[illegible]	6.0[illegible]	10[illegible]	9[illegible]	2[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	143	3.2[illegible]	6.2[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	3.[illegible]	6.458	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15:[illegible]	153	3.60	6.458	1047 / [illegible]	988 / 979	[illegible]	[illegible]	R. [illegible]
15:30	152	2.51	8.482	1051 / 1027	99[illegible] / 984	201[illegible]	1137	[illegible]
16:[illegible]	154	3.14	6.458	1046 / 1022	[illegible] / [illegible]	[illegible]	1144	[illegible]
16:30	154	2.53	6.059	105[illegible] / [illegible]	[illegible] / 987	2012	[illegible]9	[illegible]
1700	151	2.7	6.459	1055 / 1033	999 / 999	2006	1138	H. Thomas
17:30	152	[illegible]	6.456	[illegible]	994 / 984	2004	1140	R. Wasko
18:00	152	3.3	6.[illegible]	1051 / [illegible]	99[illegible] / 986	[illegible]	1137	R. Wasko
18:30	[illegible]	3.[illegible]	6.192	1035 / [illegible]	997 / [illegible]	2011	1141	R. Wasko
1900	152	2.8	6.458	1048 / 1030	995 / 986	2009	1140	H. Thomas
19:30	152	3.4	5.792	1048 / [illegible]	[illegible]	2007	1137	R. Wasko
20:00	152	2.33	5.792	10[illegible] / 1034	1003 / 993	[illegible]	[illegible]	R. Wasko
2030	152	2.8	6.059	1050 / 1035	999 / 989	2014	1135	H. Thomas
21:00	151	[illegible]	6.0[illegible]	[illegible]	99[illegible] / 98[illegible]	2010	1136	R. Wasko
21:30	151	[illegible]	6.[illegible]	10[illegible] / 103[illegible]	1006 / [illegible]	[illegible]	1139	R. Wasko

PROCESS DATA LOG NO. 1: POWER PLANT CONTROL ROOM
(Take data every one-half hour)

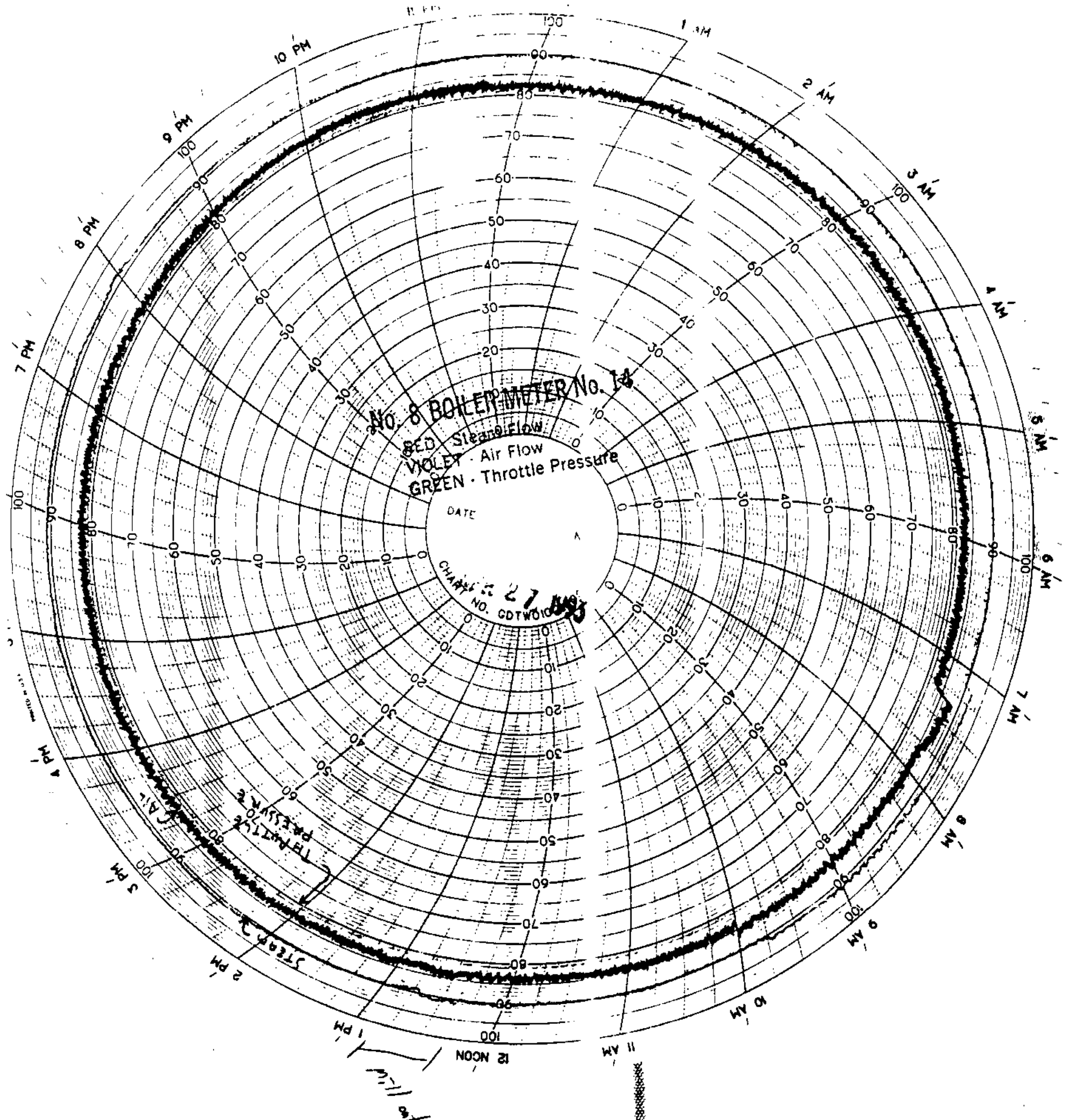
Date: 5-1-[illegible]

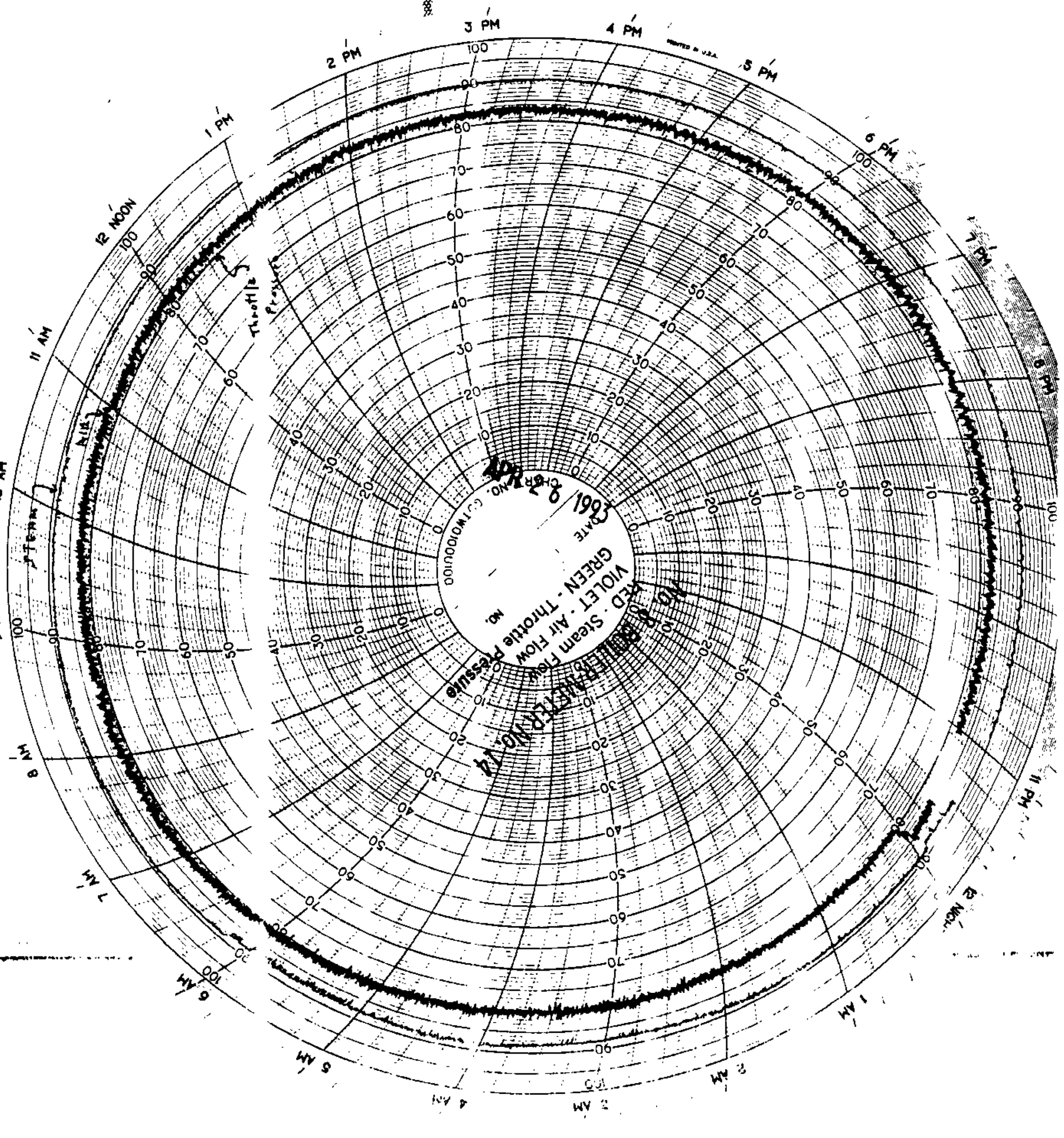
Time	Load, MW	Excess Oxygen, percent	Stack Opacity, percent	Steam temp., F		Steam Pres., psig	Steam Generation Rate, klb/hr	Data Taker
				SH Outlet	RH Outlet			
[illegible]	151	[illegible]	[illegible]	[illegible]/1047	[illegible]	[illegible]	1124	[illegible]
0830	151	3.19	[illegible]	1048/[illegible]	1005/[illegible]	200[illegible]	1122.8	R. Vecke[illegible]
[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]57	[illegible]
[illegible]	151	3.5[illegible]	6.[illegible]	[illegible]	[illegible]	200[illegible]	1123.3	[illegible]
[illegible]	152	3.26	6.[illegible]	[illegible]/1045	1003/994	[illegible]14	1126.6	[illegible]
[illegible]								
[illegible]	147	4.72	6.458	[illegible]	[illegible]	2016	1103.3	[illegible]
[illegible]	151	[illegible]	6.72[illegible]	[illegible]	100[illegible]/991	2009	[illegible]	[illegible]
[illegible]	151	[illegible]	6.4[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Vecker
[illegible]	[illegible]	[illegible]	6.2[illegible]	1055/1037	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	152	3[illegible]	6.726	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	152	[illegible]	6.726	1049/[illegible]	1001/992	200[illegible]	11319	[illegible]
[illegible]	151	[illegible]	[illegible]	[illegible]/1035	[illegible]	2006	1128.8	R. Vecker
[illegible]	152	3.27	6.458	[illegible]/1042	1003/993	[illegible]	1127	[illegible]
[illegible]	152	3.2[illegible]	[illegible]860	[illegible]	1008/[illegible]	[illegible]07	1126.6	[illegible]
1530	152	3.67	8.348	1053/1051	[illegible]	2006	1128.1	[illegible]
1600	152	2.87	6.4[illegible]	1050/1049	[illegible]	2007	1131.3	R. Vecker
1630	151	3.[illegible]	6.72[illegible]	[illegible]	[illegible]	2006	1117.6	R. Vecker
1700	151	3.75	7.127	1047/[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1830	150	4.09	7.669	1030/[illegible]	[illegible]/972	[illegible]	[illegible]43.7	R. Vecker
1900	151	3.77	6.6[illegible]	[illegible]	[illegible]	2007	1137.[illegible]	R. Vecker
1930	151	2.97	6.995	10[illegible]/1026	991/981	2005	1134	R. Weber
2000	151	3.12	7.601	[illegible]	[illegible]	20[illegible]	1137.[illegible]	R. Vecker

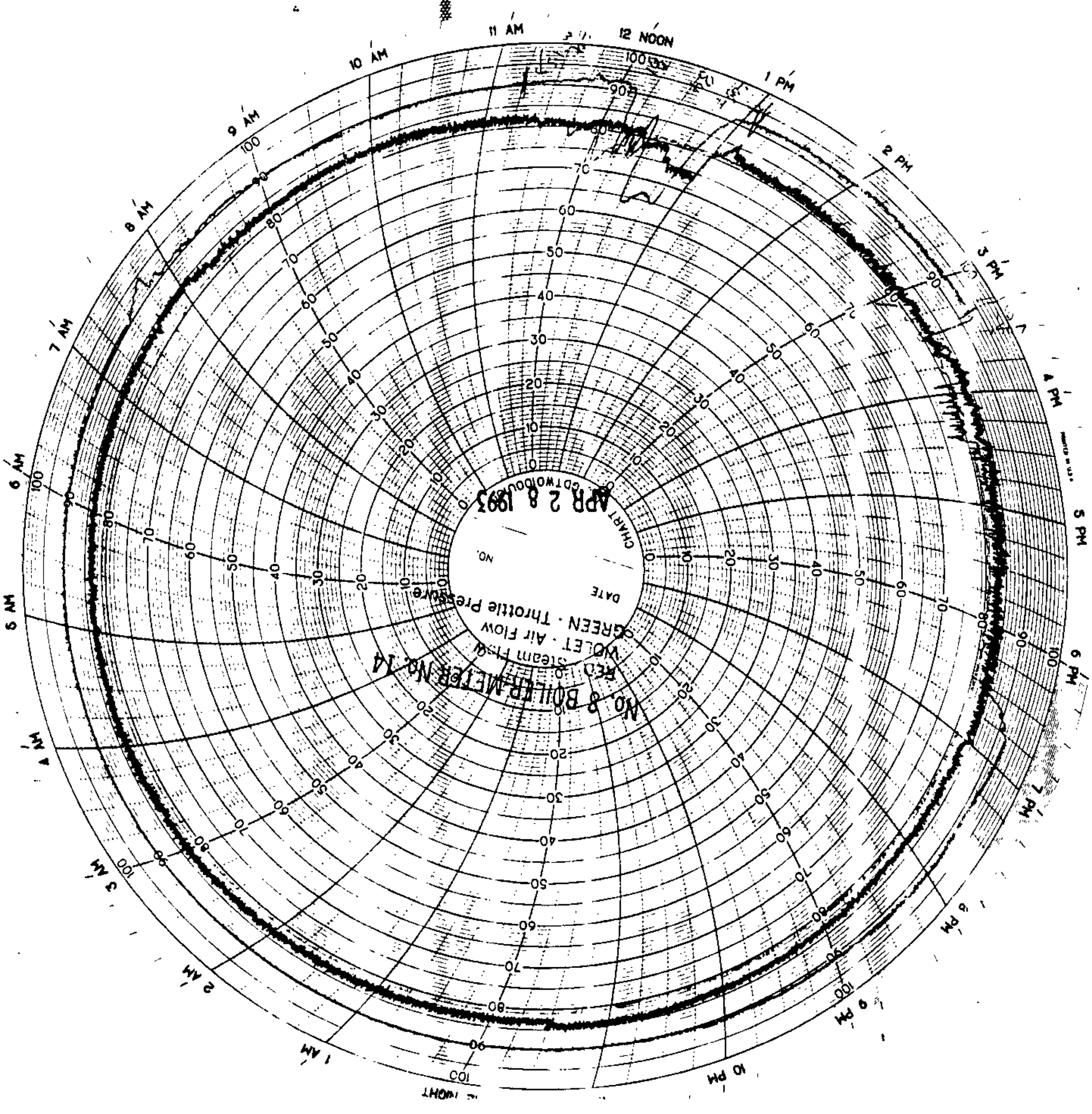
PROCESS DATA LOG NO. 1: POWER PLANT CONTROL ROOM
(Take data every one-half hour)

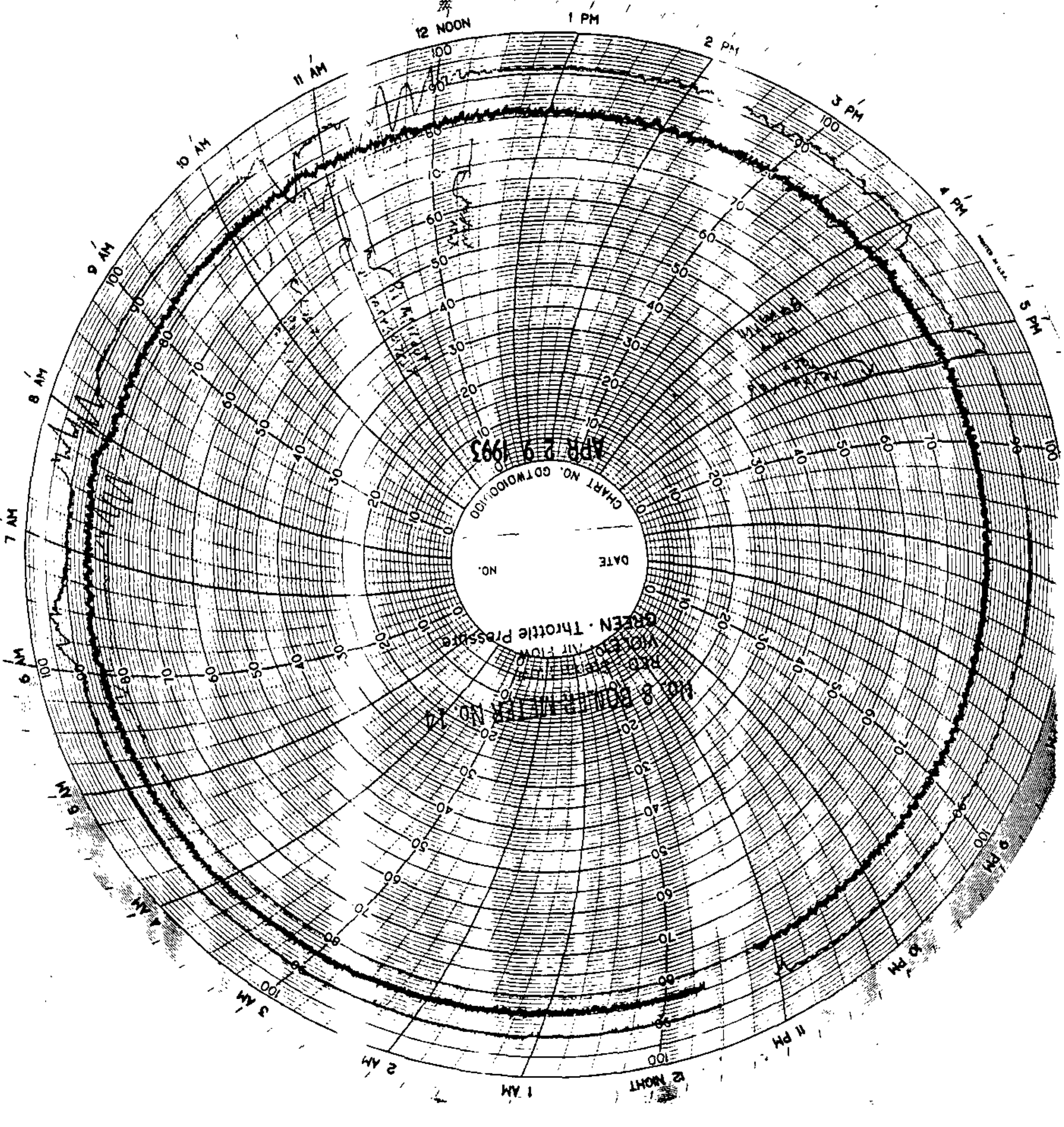
Date: 5-2-93

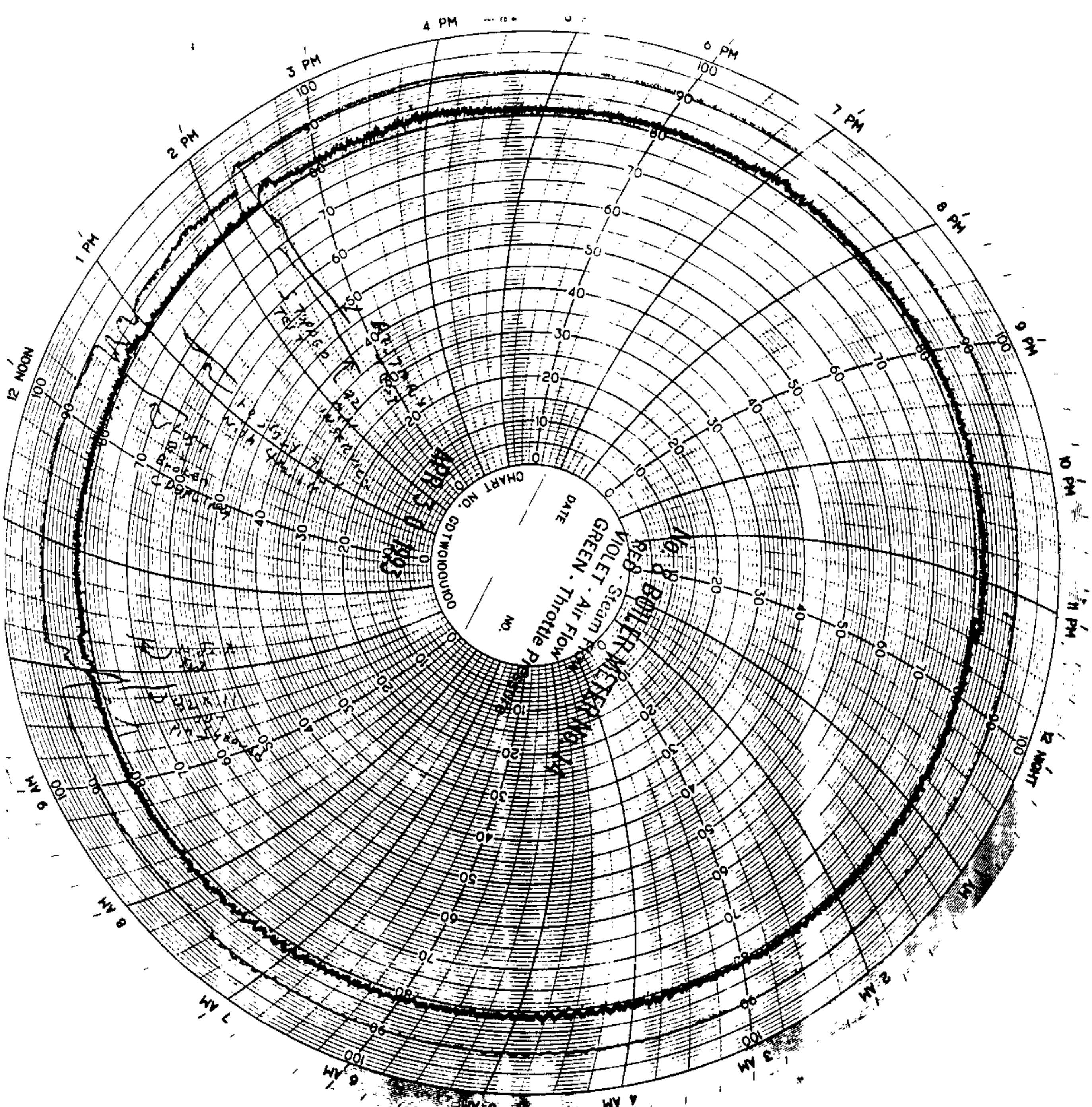
Time	Load, MW	Excess Oxygen, percent	Stack Opacity, percent	Steam temp., F		Steam Pres., psig	Steam Generation Rate, lb/hr	Data Taker
				SH Outlet	RH Outlet			
0800	[illegible]	4.1	8.348	1050/1041	[illegible]	2000	1121	[illegible]
0830	151	3.44	[illegible]	[illegible]	[illegible]	2014	1134	[illegible]
0900	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0930	15[illegible]	[illegible]	7.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1000	150	2.65	8.484	1048/1034	[illegible]/984	200[illegible]	[illegible]	[illegible]
1030	151	2.91	7.314	104[illegible]	[illegible]	20[illegible]	[illegible]	[illegible]
1100	150	3.79	7.583	105[illegible]/1031	991/951	2013	1137	R. [illegible]
1130								
1200	151	3.7[illegible]	8.076	[illegible]	986/976	2008	1138	[illegible]
1230	150	3.36	7.504	1046/1019	981/[illegible]	2004	1135	[illegible]
1300	151	2.31	8.259	103[illegible]	989/979	2011	1134	[illegible]
1330	151	3.37	7.129	[illegible]/1031	98[illegible]/979	2004	1134	[illegible]
1400	151	3.03	6.726	1053/1025	[illegible]	2008	1136	R. [illegible]
1430	151	3.87	7.129	1052/1025	99[illegible]/984	2004	1135	[illegible]
1500								
1530	151	3.16	7.122	1047/1035	993/982	2014	1133	GORDON
1600	151	2.7	6.592	1052/1044	998/988	2012	1126	H. Thomas
1630	151	4.2	6.927	1053/1048	1001/991	2012	1124	H. Thomas
1700	150	2.8	6.458	1048/1046	992/987	2012	1120	H. Thomas
1730	150	4.0	7.129	1052/1049	1002/990	2007	1115	H. Thomas
1800	151	3.5	7.129	1051/1044	998/[illegible]	2002	1120	GORDON
1830	149	3.4	6.995	1046/1048	1002/991	2015	1107	H. Thomas

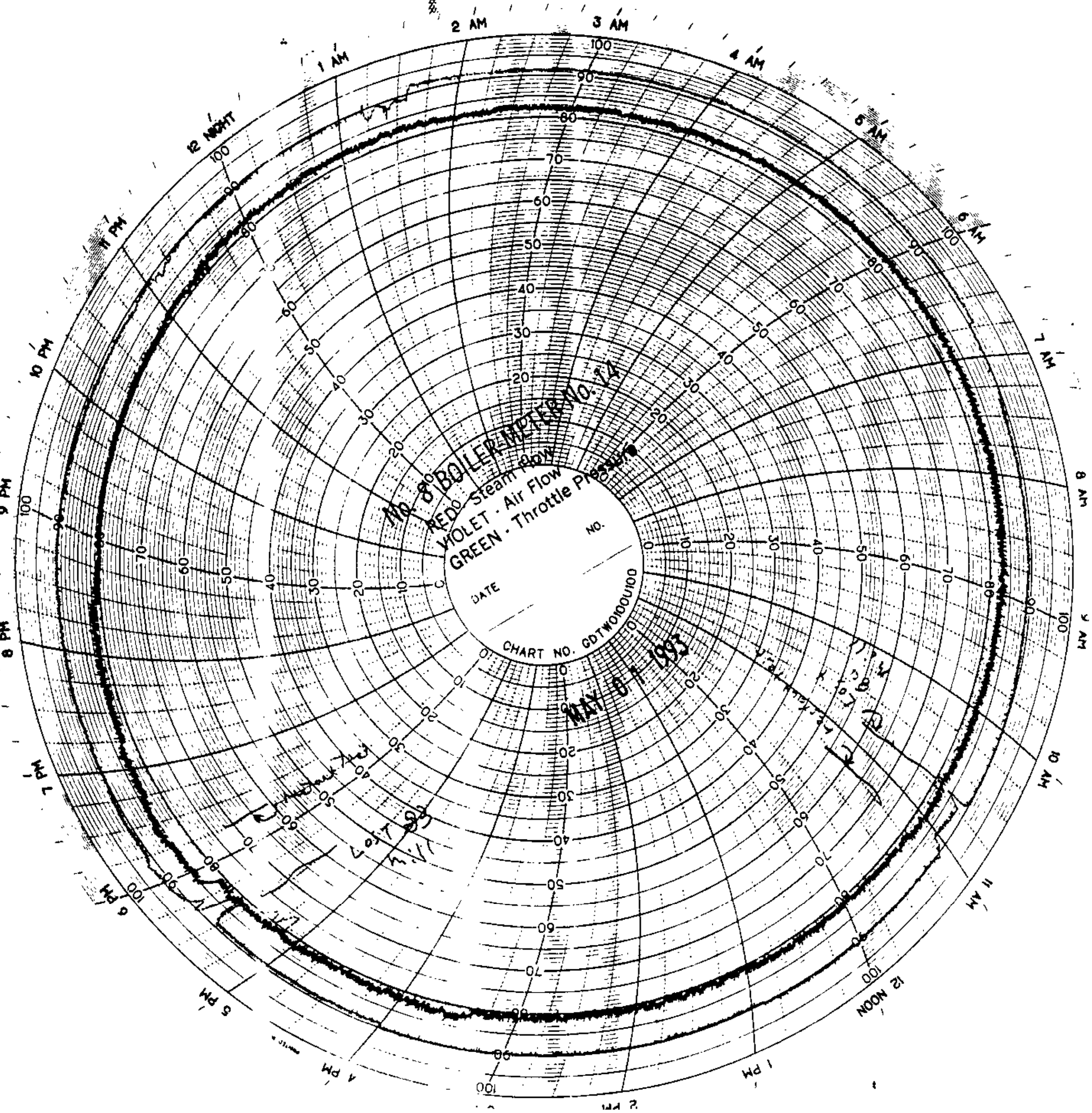

No. 8 BOILER METER No. 14
RED - Steam Flow
VIOLET - Air Flow
GREEN - Throttle Pressure
DATE
CHART NO. GDTW010
STEAM
AIR
THROTTLE PRESSURE
12 NOON
1 PM
2 PM
3 PM
4 PM
7 PM
8 PM
9 PM
10 PM
1 AM
2 AM
3 AM
4 AM
5 AM
6 AM
7 AM
8 AM
9 AM
10 AM
11 AM

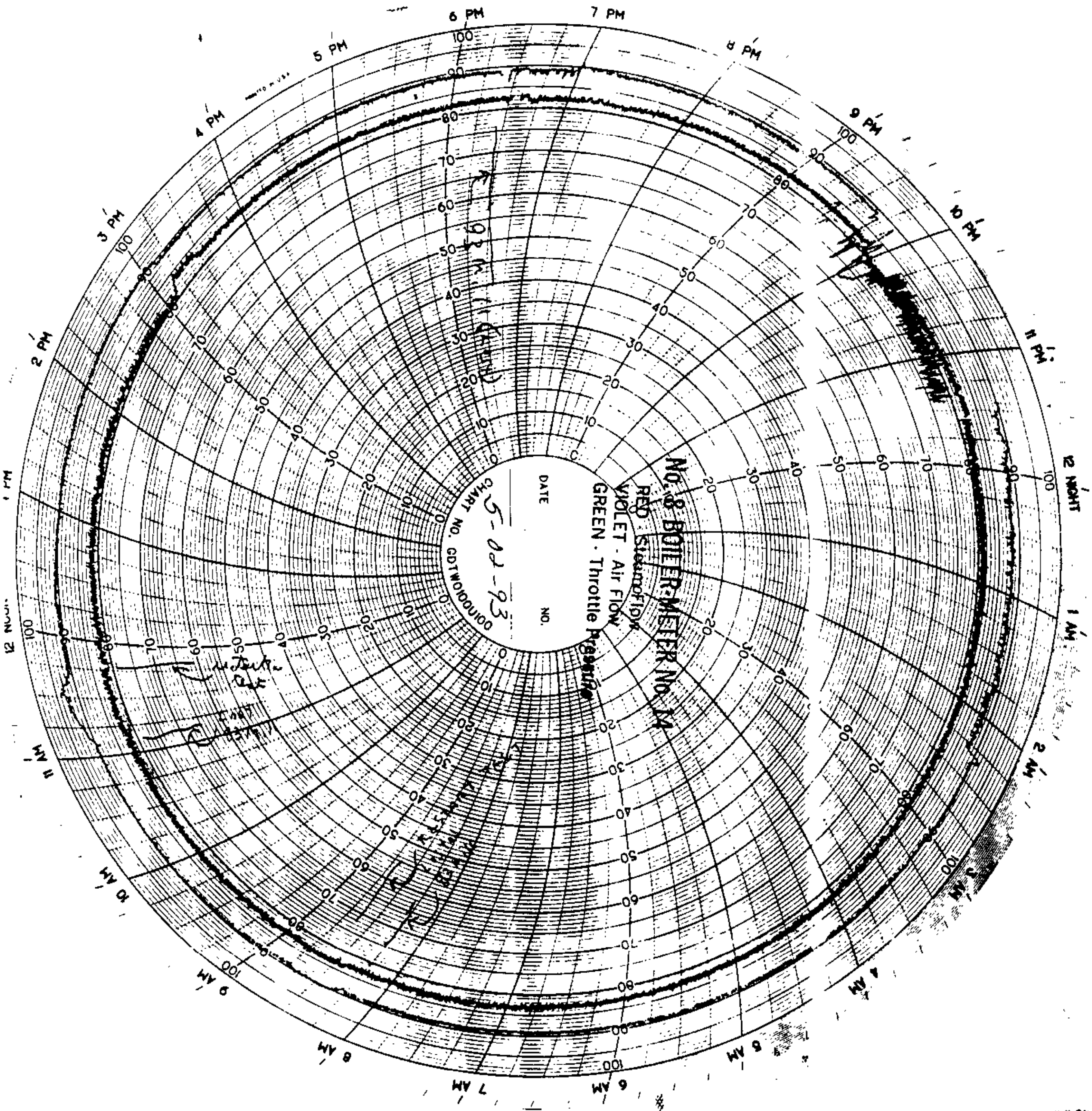

RED - Steam Flow
VIOLET - Air Flow
GREEN - Throttle Pressure
DATE
CHART NO.
12 NOON
1 PM
2 PM
3 PM
4 PM
5 PM
6 PM
7 PM
8 PM
11 PM
12 NIGHT
1 AM
5 AM
7 AM
8 AM
9 AM
10 AM
11 AM
Steam
Air
Throttle Pressure


No. 8 BOILER METER No. 14
RED - Steam Flow
VIOLET - Air Flow
GREEN - Throttle Pressure
DATE
NO.
CHART
APR 2 8 1993
12 NOON
1 PM
2 PM
3 PM
4 PM
5 PM
6 PM
7 PM
8 PM
9 PM
10 PM
MIDNIGHT
1 AM
2 AM
3 AM
4 AM
5 AM
6 AM
7 AM
8 AM
9 AM
10 AM
11 AM


12 NOON
1 PM
2 PM
3 PM
4 PM
5 PM
6 PM
10 PM
11 PM
12 NIGHT
1 AM
2 AM
3 AM
4 AM
6 AM
7 AM
8 AM
9 AM
10 AM
11 AM
APR 2 9 1993
CHART NO.
DATE
NO.
GREEN - Throttle Pressure
No. 8 BOILER METER No. 14


No. 8 BOILER METER No. 14
RED - Steam Flow
VIOLET - Air Flow
GREEN - Throttle Pressure
CHART NO. GDTW0100U100
DATE
NO.
APR 13 1953


No. 8 BOILER METER NO. 14
RED · Steam Flow
VIOLET · Air Flow
GREEN · Throttle Pressure
NO.
DATE
CHART NO. GDTW010000100
MAY 0 6 1993
12 NIGHT
1 AM
2 AM
3 AM
4 AM
5 AM
6 AM
7 AM
8 AM
9 AM
10 AM
11 AM
12 NOON
1 PM
2 PM
4 PM
5 PM
6 PM
7 PM
8 PM
9 PM
10 PM
11 PM


No. 8 BOILER METER No. 14
RED - Steam Flow
VIOLET - Air Flow
GREEN - Throttle Pressure
DATE
5-02-93
NO.
CHART NO. GDTW00100
12 NOON
1 PM
2 PM
3 PM
4 PM
5 PM
6 PM
7 PM
8 PM
9 PM
10 PM
11 PM
12 NIGHT
1 AM
2 AM
3 AM
4 AM
5 AM
6 AM
7 AM
8 AM
9 AM
10 AM
11 AM

SNRB™ PROCESS DATA
(PROCESS DATA LOG NO. 2)

Date: 4/27/93

PROCESS DATA LOG NO. 2: SNRB SYSTEM
(Instantaneous data; record data every one-half hour)

Time	Baghouse Pres. Drop, in. water	Modules on Line	Feed Rate, lb/hr			Propane Indicator Reading ft³	SO2, ppm		NOX, ppm		Opacity, percent	Data Taker
			Sorbent	Ammonia	Atom. Air		In	Out	In	Out		
1030	11.8	(3 OFF) 5	455	9.29		210661					1.6	ARH
1115	11.7	5	415	9.25							1.5	ARH
1207	11.8	5	445	9.84								ARH
1305	11.9	5	420	8.84							1.5	JMM
1400	11.5	5	503	10.21							1.5	JMM
1445	11.4	5	455	~~9.43~~ 9.43							1.4	ARH
1530	11.5	5	445	9.52							1.4	ARH
1615	11.5	5	465	9.56							1.4	ARH
1705	11.5	5	455	9.94							1.4	ARH
1745	11.4	5	450	10.01							1.4	ARH
1830	11.5	5	446	10.06							1.4	JMM
1915	11.37	5	439	9.22							1.3	APE
2100* ~~2030~~	11.54	5	466	9.35							1.5	APE
2145	11.44	5	442	9.27							1.5	APE
2230	11.47	5	457	9.26							1.6	APE
2315	11.44	5	444	9.30							1.6	APE
0000	11.43	5	445	9.31							1.5	APE

*did not take readings as B&W calibration in process

449.8 9.52

Date: 4/26/93

Data Sheet No. 5: Additional SNRB Data
(take data every one-half hour)

Time	SNRB Inlet			Baghouse Inlet			Baghouse Outlet			Baghouse Temp, F	Data Taker
	O_2, %	SO_2, ppm	NO_x, ppm	O_2, %	SO_2, ppm	NO_x, ppm	O_2, %	SO_2, ppm	NO_x, ppm		
1130	4.6	2500	530	4.5	2010	440	6.0	200	40	848	ARH
1200	4.7	2450	535	4.5	2080	440	5.8	195	41	853	ARH
1230	4.3	2560	530	4.4	2090	430	5.7	165	40	847	ARH
1300	4.6	2490	525	4.5	2050	435	5.7	~~2~~ 190 ARH	40	848	ARH
1330	4.4	2500	538	4.5	2040	425	5.7	240	43	848	ARH
1400	4.6	2420	515	4.4	2040	420	5.9	125	43	845	ARH
1430	4.4	2490	540	4.5	2035	430	5.5	165	45	855	ARH
1530	4.6	2518	539	4.2	2138	427	5.2	154	45	857	JMM
1600	4.7	2508	537	4.3	2147	424	5.2	197	33.7	858	JMM
1630	4.2	2530 JMM	524	4.5	2091	423	5.6	207	27.3	859	JMM
1700	3.8	2657	459	3.9	2230	380	4.9	160	21.9	859	JMM
1730	4.4	2596	509	4.5	2108	416	6.7	257	24.2	859	JMM
1800	4.2	2491	490	4.7	2050	407	6.0	220	38.9	846	JMM
1830	4.08	2463	505	4.26	2089	423	5.9	206	40.6	843	JMM
1900	4.5	2483	531	4.47	2088	429	6.08	372	69.2	842	JMM
1930	4.16	2549	512	4.29	2126	415.5	5.81	167	54.5	844	JMM
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Date: 4/26/93

Data Sheet No. 5: Additional [illegible] [illegible]
(take data every one-half hour)

Time	SNRB Inlet			Baghouse Inlet			Baghouse Outlet			Baghouse Temp, F	Data Taker
	O_2, %	SO_2, ppm	NOx, ppm	O_2, %	SO_2, ppm	NOx, ppm	O_2, %	SO_2, ppm	NOx, ppm		
2030	3.94	2651	528	4.35	2175	435	5.73	332	63	847	JMM
2230	4.49	2645	502	4.27	2177	427	5.48	178	40	859	APE
2300	4.87	2534	517	4.60	2116	430	6.22	315	34	852	APE
2330	4.70	2539	513	4.36	2165	438	5.81	199	38	850	APE
~~0000~~	4.41	2591	508	4.13	2165	436	5.60	348	41.4	848	APE
0030	5.37	2326	517	4.53	2075	431	5.94	152	37.9	848	APE
0100	4.50	2575	528	4.19	2158	438	5.39	178	44.3	847.5	APE
0130	5.34	2347	529	5.03	2063	410	6.29	156	42.4	849	APE
0200	4.58	2580	531	4.41	2161	444	5.72	155	41.1	848	APE
0230	4.52	2668	525	4.31	2180	441	5.55	218	51.6	848	APE

Date: 4/26/93

PROCESS DATA LOG NO. 2: SNRB SYSTEM
(Instantaneous data; record data every one-half hour)

Time	Baghouse Pres. Drop, in. water	Modules on Line	Feed Rate, lb/hr			Propane Indicator Reading (ft³)	SO_2, ppm		NOX, ppm		Opacity, percent	Data Taker
			Sorbent (BM)	Ammonia	*Atom. Air		In	Out	In	Out		
0900	11.53	#3 OFF 5	486	9.10		@ 0845 600,935	2110	185	444	55	2.0	ARH
0930	11.7	" 5	476	9.24			2150	205	435	46	2.0	ARH
1000	11.65	5	480	9.23			2100	190	440	40	2.1	ARH
1030	11.4	5	465	9.13			2030	180	445	40	2.2	ARH
1100	11.7	5	480	~~9.13~~ ARH 9.12			2050	137	437	~~40~~ 42	2.1	ARH
1130	11.6	5	475	9.11							2.2	ARH
1200	11.45	5	475	9.10							2.2	ARH
1230	11.8	5	480	9.09							**1.6	ARH
1300	11.6	5	485	9.07							1.6	ARH
1330	11.4	5	470	9.08							1.6	ARH
1400	11.85	5	470	9.07							1.6	ARH
1430	11.7	5	470	9.20							1.6	ARH
1530	11.84	5	483	9.6°							1.6	JMM
1600	11.69	5	485	9.62							1.7	JMM
1630	11.61	5	478	9.45							1.7	JMM
1700	11.92	5	477	9.43							1.6	JMM
1730	11.84	5	442	8.37							1.4	JMM

* collected raw data for orifice calc.

** OPACITY MONITOR WENT THROUGH AUTOCAL AT ~ 1210

Date: 4/26/93

PROCESS DATA LOG NO. 2: SNRB SYSTEM
(Instantaneous data; record data every one-half hour)

Time	Baghouse Pres. Drop, in. water	Modules on Line	Feed Rate, lb/hr			Propane Indicator Reading	SO2, ppm		NOX, ppm		Opacity, percent	Data Taker
			Sorbent 3m	Ammonia	Atom. Air		In	Out	In	Out		
1800	12.00	5	473	8.36		BAR. PRESS 29.51					1.6	JMM
1830	11.90	5	445	8.35							1.6	JMM
1900	11.53	5	485	8.47							1.6	JMM
1930	11.69	5	512	8.82							1.6	JMM
2000	11.64	5	471	8.81							1.5	APE
2030	11.53	5	515	8.80							1.5	JMM
											.	-
2230	11.54	5	488	~~8.85~~ 9.25		29.62					1.6	APE.
2300	11.51	5	448	9.01		29.62					1.6	APE
2330	11.41	5	470	9.02		"					1.6	APE
0000	11.29	5	480	9.00		"					1.6	APE.
0030	11.64	5	454	9.00		"					1.6	APE
0100	11.62	5	499	8.98		"					1.6	APE
0130	11.59	5	463	8.96		"					1.6	APE
0200	11.74	5	465	8.86		"					1.6	APE
0230	11.48	5	484	8.91		"					1.6	APE

475.9 9.02

Date: 4/27/93

Data Sheet No. 5: Additional SNRB Data
(take data every one-half hour)

Time	SNRB Inlet			Baghouse Inlet			Baghouse Outlet			Baghouse Temp, F	Data Taker
	O_2, %	SO_2, ppm	NOx, ppm	O_2, %	SO_2, ppm	NOx, ppm	O_2, %	SO_2, ppm	NOx, ppm		
1030	4.7	2280	470	4.8	1900	390	5.6	200	21	856	ARH
1115	5.0	2150	540	4.9	1830	435	6.0	185	40	857	ARH
1207	4.6	2200	540	4.5	1850	440	5.8	200	26	853	ARH
1305	5.1	2198	529	5.4	1829	393	6.6	224	64	853	JMM
1400	4.3	2253	524	4.6	1913	423	5.9	211.7 ~~232~~	39.1	852	JMM
1445	4.4	2300	530	4.3	2000	420	5.5	220	25	855	ARH
1530	4.5	2300	520	4.4	2050	425	5.6	250	34	854	ARH
1615	4.3	2400	550	4.1	2100	440	5.3	270	43	855	ARH
1705	4.5	2300	535	4.0	2050	420	5.3	265	33	857	ARH
1745	4.3	2300	540	4.2	2050	430	5.3	260	28	860	ARH
1830	3.98	2295	491	3.89	2084	428	5.15	297	24	858	JMM
1915	4.15	2313	532	4.24	2034	436	5.47	236	23	857	APE
2100*	4.50	2394	516	4.32	1989	429	5.57	167	38	854	APE
2145	4.36	2379	506	4.21	1996	436	5.51	184	32	854	APE
2230	4.66	2453	536	4.57	1974	423	5.86	159	44.6	853	APE
2315	4.82	2278	527	4.56	1926	445	5.77	128	45	852	APE
~~0000~~	5.06	2225	516	4.56	1924	432	5.62	99	44	850	APE
0045	4.73	2372	533	4.59	1921	443	5.75	151	48	855	APE
~~2017~~											
		2299.4									

Date: 4/28/93

PROCESS DATA LOG NO. 2: SNRB SYSTEM
(Instantaneous data; record data every one-half hour)

Time	Baghouse Pres. Drop, in. water	Modules on Line	Feed Rate, lb/hr			Propane Indicator Reading	SO2, ppm		NOX, ppm		Opacity, percent	Data Taker
			Sorbent	Ammonia	Atom. Air		In	Out	In	Out		
0845	11.46	5	448	9.20							1.6	APE
1017	10.59	5	397	6.78							1.7	JMM
1258	11.40	5	358	7.73							1.6	JMM
1400	11.0	5	425	9.09							1.5	ARH
1530	11.1	5	430	9.55							1.4	ARH
1615	11.69	5	368	6.45							1.5	JMM

Date: 4/28/93

Data Sheet No. 5: Additional SNRB Data
(take data every one-half hour)

Time	SNRB Inlet			Baghouse Inlet			Baghouse Outlet			Baghouse Temp, F	Data Taker
	O_2, %	SO_2, ppm	NOx, ppm	O_2, %	SO_2, ppm	NOx, ppm	O_2, %	SO_2, ppm	NOx, ppm		
1017	4.9	23165	487	4.6	1890	399.5	5.9	49.4	62.0	846	JMM
1258	6.1	2086	315	5.8	1820	265	6.90	116	9.2	854	JMM
1400	4.6	2270	500	4.1	1980	390	5.6	230	36	856	GRH
1530	4.7	2230	490	3.8	1970	400	5.2	240	32	856	GRH
1615	3.9	2260	332	3.7	1998	298	5.1	214	16	856	JMM

Date: 4/29/93

PROCESS DATA LOG NO. 2: SNRB SYSTEM
(Instantaneous data; record data every one-half hour)

Time	Baghouse Pres. Drop, in. water	Modules on Line	Feed Rate, lb/hr			Propane Indicator Reading	SO2, ppm		NOX, ppm		Opacity, percent	Data Taker
			Sorbent	Ammonia	Atom. Air		In	Out	In	Out		
0900	12.1	5	410	8.99	215						2.0	ARH
0950	12.0	5	410	9.42	215						1.9	ARH
1115	12.0	5	420	10.13	207						1.6	ARH
1225	11.7	5	425	10.08	206						1.7	ARH
1300	12.0	5	415								1.6	ARH
1345	11.8	5	430	9.76							1.5	ARH
1430	11.7	5	440	9.89 ARH							1.5	ARH
1545	12.1	5	430	9.47							1.6	ARH
1730	12.1	5	460	8.59							1.7	ARH
1900	12.1	5	470	8.66							1.7	MQK
1945	12.0	5	471	9.3							1.7	APE
2030	12.2	5	480	9.18							1.58	APE
2115	12.4	5	462	9.04							1.58	APE
2200	12.43	5	455	9.05							1.70	APE

Data Sheet No. 5: Additional SNRB Data
(take data every one-half hour)

Date: 4/29/93

Time	SNRB Inlet			Baghouse Inlet			Baghouse Outlet			Baghouse Temp, F	Data Taker
	O_2, %	SO_2, ppm	NO_x, ppm	O_2, %	SO_2, ppm	NO_x, ppm	O_2, %	SO_2, ppm	NO_x, ppm		
0900	4.4	2100	475	4.5	1750	400	5.5	240	44	853	ARH
0950	4.7	2200	490	4.5	1750	410	5.8	180	27	852	ARH
1115	4.3	2200	370	4.1	1850	300	5.4	230	19	852	ARH
UNSTABLE 1225	4.2	2200	470	4.0	1850	300	5.3	250	25	856	ARH
1300	4.3	2150	470	4.0	1900	390	5.3	250	35	854	ARH
1345	4.3	2200	475	4.0	1900	385	5.3	250	35	856	ARH
1430	4.4	2200	460	4.2	1950	380	5.3	350	22	857	ARH
1545	4.3	2050	450	4.3	1950	370	5.3	400	19	858	ARH
1730	3.8	2400	465	3.7	2050	370	4.9	450	45	857	ARH
1900	4.1	2350	500	3.8	1995	398	5.1	350	57	860	MAZ
1945	4.18	2352	514	3.99	2019	405	5.2	508	35	857	APE
2030	4.72	2347	511	4.24	1958	409	5.57	212	29	855	APE
2115	4.64	2366	504	4.25	~~18~~ APE 1922	393	5.55	189	29	854	APE
2200	4.51	2417	511	4.05	1964	420	5.37	180	36.8	852	APE

Date: 4/30/93

PROCESS DATA LOG NO. 2: SNRB SYSTEM
(Instantaneous data; record data every one-half hour)

Time	Baghouse Pres. Drop, in. water	Modules on Line	Feed Rate, lb/hr			Propane Indicator Reading	SO2, ppm		NOX, ppm		Opacity, percent	Data Taker
			Sorbent	Ammonia	Atom. Air		In	Out	In	Out		
0915	12.0	5	460	9.05							2.0	GRH
1030	12.2	5	455	8.95							2.0	GRH
1145	12.1	5	450	9.43							1.9	GRH
1230	12.0	5	460								1.5	GRH
1345	12.1	5	445								1.5	GRH
1430	11.7	5	450	9.24							1.5	GRH
1525	11.8	5	460	9.24							1.5	GRH
1615	12.1	5	455	10.04							1.4	GRH
1700	12.0	5	460	10.04							1.4	GRH
1745	12.0	5	465	9.69							1.4	GRH
1830	11.92	5	457	APE 9.63							1.6	APE
1915	12.02	5	477	APE 9.66							1.5	APE
2000	12.02	5	468	APE 9.67							1.5	APE
2045	12.09	5	451	9.66							1.5	APE

Data Sheet No. 5: Additional SNRB Data
(take data every one-half hour)

Date: 4/30/93

Time	SNRB Inlet			Baghouse Inlet			Baghouse Outlet			Baghouse Temp, F	Data Taker
	O_2, %	SO_2, ppm	NOx, ppm	O_2, %	SO_2, ppm	NOx, ppm	O_2, %	SO_2, ppm	NOx, ppm		
0915	4.6	2250	500	4.2	1900	400	5.5	200	32	854	ARH
1030	4.5	2250	500	4.3	1850	400	5.5	200	46	852	ARH
1145	4.7	2300	510	4.4	1900	410	5.4	220	45		
1230	4.4	2350	500	4.2	1950	405	5.4	210	34	855	ARH
1345	5.1	2150	400	5.0	1800	315	6.0	225	27	853	ARH
1430	4.9	2250	530	4.5	1800	420	5.6	270	69	856	ARH
1525	4.6	2300	525	4.4	1950	420	5.3	290	42	855	ARH
1615	4.8	2350	520	4.4	1950	415	5.5	250	32	856	ARH
1700	4.8	2350	515	4.4	1950	415	5.5	250	28	856	ARH
1745	4.6	2350	520	4.3	1950	415	5.5	200	33	855	ARH
1830	5.0	2218	492	~~5.0~~ 4.6	1941	412	5.6	236	30	857	APE
1915	4.4	2373	514	4.3	1939	418	5.2	229	39	857	APE
2000	4.4	2444	534	4.2	1943	433	5.5	252	38	857	APE
2045	5.0	2304	520	4.6	1922	426	5.8	218	36	856	APE

Date: 5/1/93

PROCESS DATA LOG NO. 2: SNRB SYSTEM
(Instantaneous data; record data every one-half hour)

Time	Baghouse Pres. Drop, in. water	Modules on Line	Feed Rate, lb/hr			Propane Indicator Reading	SO2, ppm		NOX, ppm		Opacity, percent	Data Taker
			Sorbent	Ammonia	Atom. Air		In	Out	In	Out		
0830	11.6	5	425	8.73		28092					1.9	ARH
0915	11.7	5	415	8.69							1.9	ARH
1000	12.1	5	425	8.65							1.9	ARH
1045	12.0	5	420	6.80*							1.6	ARH
1130	11.8	5	430	8.19							1.4	ARH
1215	11.6	5	440	8.20							1.6	ARH
1300	12.0	5	450	8.26								ARH
1345	12.2	5	465	8.34							1.5	ARH
1430	12.2	5	470	8.45							1.5	ARH
1515	12.3	5	490	8.45							1.5	ARH
1600	12.2	5	465	8.58							1.5	ARH
1645	12.2	5	465	8.64							1.5	ARH
1730	12.2	5	480								1.5	ARH
1815	12.1	5	475								1.6	ARH
1900	12.4	5	495								1.6	APE
1945		EEC	Finished			sampling	at 1945					APE

* Adjusted down for mill trip

Date: 5/1/93

Data Sheet No. 5: Additional SNRB Data
(take data every one-half hour)

Time	SNRB Inlet			Baghouse Inlet			Baghouse Outlet			Baghouse Temp, F	Data Taker
	O_2, %	SO_2, ppm	NO_x, ppm	O_2, %	SO_2, ppm	NO_x, ppm	O_2, %	SO_2, ppm	NO_x, ppm		
0830	4.9	2150	530	4.6	~~#~~1800	~~460~~ 440 ARH	5.8	225	30	854	ARH
0915	4.9	2150	530	4.6	1775	440	5.8	125	19	852	ARH
1000	5.0	~~25~~ 2200 ARH	530	4.6	1800	440	5.8	200	18	854	ARH
1045	4.8	2150	530	4.6	1800	445	5.8	150	19	855	ARH
1130	4.8	2150	540	4.6	1850	450	5.7	350	38	854	ARH
1215	4.8	2150	550	~~440~~ ARH	1800	450	5.7	400	33	855	ARH
1300	4.5	2300	530	4.3	1990	450	5.4	230	27		ARH
1345	4.4	2350	540	4.3	2000	440	5.5	240	27	855	ARH
1430	4.3	2400	520	4.3	2020	430	5.4	250	28	858	ARH
1515	4.5	2400	510	4.2	2050	430				857	ARH
1600	4.5	2400	515	4.3	2000	430	5.5	200	35	857	ARH
1645	4.7	2350	510	4.5	1950	440	5.8	250	33	854	ARH
1730	4.6	2400	510	4.6	1980	430	5.8	300	27	854	ARH
1815	4.5	2450	510	4.5	2000	430	5.8	300	44	854	ARH
1900	4.8	2384	500	4.6	2094	439	5.7	251	29	855	APE
1945											APE

Date: 5/2/93

PROCESS DATA LOG NO. 2: SNRB SYSTEM
(Instantaneous data; record data every one-half hour)

Time	Baghouse Pres. Drop, in. water	Modules on Line	Feed Rate, lb/hr			Propane Indicator Reading	SO2, ppm		NOX, ppm		Opacity, percent	Data Taker
			Sorbent	Ammonia	Atom. Air		In	Out	In	Out		
0945	12.2	5	485	9.79							2.3	ARH
1030	12.2	5	475	9.71							2.0	ARH
1115	12.0	5									1.9	ARH
1230	12.2	5	475	9.46							1.6	ARH
1315	12.1	5	465	9.58							1.6	ARH
1445	12.1	5	465	10.11							1.6	ARH
1530	12.3	5	475	10.12							1.6	ARH
1615	12.2	5	465	10.15							1.6	ARH
1700	12.3	5	460								1.6	ARH
1750	12.3	5									1.6	ARH

Data Sheet No. 5: Additional SNRB Data
(take data every one-half hour)

Date: 5/2/93

Time	SNRB Inlet			Baghouse Inlet			Baghouse Outlet			Baghouse Temp, F	Data Taker
	O_2, %	SO_2, ppm	NOx, ppm	O_2, %	SO_2, ppm	NOx, ppm	O_2, %	SO_2, ppm	NOx, ppm		
0945	4.7	2490	530	4.4	2100	440	5.8	160	29	850	ARH
1030	4.7	2450	525	4.3	2050	440	5.7	210	27	851	ARH
1115	4.5	2500	510	4.2	2050	420	5.7	200	20	851	ARH
and 3 1200	4.5	2400	510	4.0	2100	425	5.3	210	40	855	ARH
1315	4.5	2350	515	4.0	2100	420	5.35	266	32	862	JMM
1400	4.6	2420	515	3.9	2160	417	5.25	315	29	861	JMM
1445	4.6	2400	490	4.0	2150	415	5.3	320	28	856	ARH
1530	4.8	2350	510	4.1	2100	425	5.6	300	31	856	ARH
1615	4.8	2350	520	4.0	2100	435	5.7	260	34	857	ARH
1700	4.8	2350	520	4.0	2100	430	5.7	240	33	857	ARH
1750	4.7	2350	515	3.9	2100	430	5.6	300	32	859	ARH

ESP PROCESS DATA
(PROCESS DATA LOG NO. 3)

PROCESS DATA LOG NO. 3: ESP

(Take data ~~four~~ 3/4 times per test day)

Date: 4/26/03

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
0735	811		321	33	51/53	86	Hilton
	821		300	65	42/53	270	
	831		225		50		
	841		400		62		
	851		310		30		
	861		ON		ON		
	862		430		40		
	871		—		42		
	872		444		46		
	881		290		50		
	882		355		48		
0855	811		315	32	51/53	154	[illegible]
	821		323	63	42/51	300	
	831		200		38		
	841		410		58		
	851		300		44		
	861		[illegible]		49		
	862		330		54		
	871		[illegible]		52		
	872		440		56		
	881		300		46		
	882		360		52		

* See drawing.

ESP TR Sets

→ 811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/26/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
0955	811		325	40	51/52	122	Hilborn
	821		330	65	44/53	292	
	831		200		40		
	841		410		50		
	851		320		52		
	861		N/A		52		
	862		430		54		
	871		N/A		48		
	872		440		50		
	881		300		48		
	882		360		52		
1100	811		326	39	49/51	118	Hilborn
	821		326	65	44/54	292	
	831		200		44		
	841		400		58		
	851		320		52		
	861		N/A		49		
	862		430		56		
	871		N/A		54		
	872		440		58		
	881		300		48		
	882		360		54		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/25/92

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
1135	811		325	32	51/52	150	[illegible]
	821		329	[illegible]	43/53	292	
	831		150		44		
	841		400		54		
	851		300		48		
	861		N/A		46		
	862		440		52		
	871		N/A		52		
	872		540		56		
	881		300		50		
	882		360		52		
1235	811		326	39	51/53	150	[illegible]
	821		336	67	43/53	292	
	831		175		46		
	841		400		54		
	851		320		56		
	861		N/A		50		
	862		435		56		
	871		N/A		54		
	872		440		58		
	881		300		52		
	882		360		54		

*See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/26/93

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
1418							
	811		326	45	51/53	142	[illegible]
	821		316	65	42/53	292	
	831		150		28		
	841		400		58		
	851		310		56		
	861		N/A		56		
	862		430		58		
	871		NA		48		
	872		440		58		
	881		300		52		
	882		350		58		
1521	811		326	45	50/50	150	Hilborn
	821		316	66	42/50	292	
	831		170		40		
	841		400		54		
	851		310		50		
	861		N/A		46		
	862		[illegible]		52		
	871		NA		50		
	872		440		56		
	881		300		48		
	882		360		52		

See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/26/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
4/26/93							
16:32	811		326	50	49/51	197	[illegible]
	821		321	65	43/52	292	
	831		160		50		
	841		400		58		
	851		290		55		
	861		N/A		50		
	862		430		54		
	871		N/A		44		
	872		440		62		
	881		300		50		
	882		360		52		
17:35		4/26/93					
	811	•	306	38	52.6	102	
	821		323	65	51.8	308	
	831		230		24		
	841		380		26		
	851		310		—		
	861		No Reading		44		
	862		420		52		
	871		No Reading		38		
	872		440		52		
	881		300		46		
	882		360		50		

• See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/26/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
4/26/93							
19:15	811		322	45	50/52	173	[illegible]
	821		330	65	41/51	292	
	831		470		48		
	841		380		58		
	851		230		48		
	861		N/A		52		
	862		400		56		
	871		N/A		52		
	872		440		58		
	881		300		50		
	882		360		54		
20:15	811		323	32	51/53	142	Hilborn
	821		337	65	43/52	292	
	831		170		44		
	841		410		58		
	851		270		48		
	861		N/A		48		
	862		370		52		
	871		N/A		48		
	872		440		56		
	881		300		46		
	882		360		52		

* See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">→ 811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/26/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
21:50	811		323	20	49/51	150	STARHEIM
	821		[illegible]	[illegible]	42/53	[illegible]	
	831		150		44		
	841		380		58		
	851		230		50		
	861		N/A		52		
	862		370		46		
	871		N/A		54		
	872		440		48		
	881		300		52		
	882		360		56		
22:40	811		316	34	51/52	134	[illegible]
	821		325	69	42/52	242	
	831		123		44		
	841		380		54		
	851		220		46		
	861		N/A		52		
	862		380		54		
	871		N/A		54		
	872		440		58		
	881		310		50		
	882		360		54		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/26/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
11:39	811		(highly variable) 77 - 327	(highly variable) 16-36	(highly variable) 32 / 32	74-126	STARKE.M
	821		319	66	43/53	292	
	831		115		46		
	841		400		42		
	851		310		42		
	861		N/A		50		
	862		410		58		
	871		N/A		56		
	872		450		58		
	881		300		50		
	882		360		54		
4/27/93							
0030	811		325	39	50/50	154	Hilborn
	821		313	65	41/51	292	
	831		100		32		
	841		370		52		
	851		310		52		
	861		N/A		48		
	862		370		54		
	871		N/A		52		
	872		450		52		
	881		300		48		
	882		360		52		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/27/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
0140	811		260	30	31/50	134	Hilburn
	821		323	60	42/52	242	
	831		150		46		
	841		430		56		
	851		230		48		
	861		NA		44		
	862		400		56		
	871		NA		52		
	872		440		58		
	881		300		46		
	882		360		52		
0250	811		218	32	31/50	110	Hilburn
	821		334	66	42/53	242	
	831		150		44		
	841		410		56		
	851		300		52		
	861		N/A		50		
	862		380		50		
	871		NA		50		
	872		440		56		
	881		300		46		
	882		366		50		

* See drawing.

ESP TR Sets

→ 811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

Time	Field	~~Duct~~ DATE	Primary Side		Secondary Side	
			Voltage, V	Current, amps	Voltage, kV	Current, ma
17:00		4/26/93				
	811		306	38	52.6	102
	821		323	65	51.8	308
	831		230		24	
	841		380		26	
	851		310		—	
	861		No Reading		44	
	862		420		52	
	871		No Reading		38	
	872		440		52	
	881		300		46	
	882		360		50	

See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

Data to be collected by process sampling staff three times per test day (start, middle, end of sampling run).

Figure 4-57. Process Data Log No. 3: ESP

Time	Field	~~Bus~~ Date	Primary Side		Secondary Side	
			Voltage, V	Current, amps	Voltage, kV	Current, ma
1330		4-26-93				
	811		283		36	
	821		369		50	
	831		220		34	
	841		[illegible]		56	
	851		310		50	
	861		No Reading		42	
	862		430		58	
	871		No Reading		54	
	872		445		52	
	881		300		34	
	882		360		38	

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

Data to be collected by process sampling staff three times per test day (start, middle, end of sampling run).

Figure 4-57. Process Data Log No. 3: ESP

Time	Field	~~Bus~~ DATE	Primary Side		Secondary Side	
			Voltage, V	Current, amps	Voltage, kV	Current, ma
20:00		4/26/93				~~156~~
	811		326	37	46-48	150
	821		337	60	44-55	292
	831		210		42	
	841		410		48	
	851		290		46	
	861		No Reading		44	
	862		410		50	
	871		No Reading		48	
	872		440		50	
	881		300		52	
	882		360		43	

See drawing.

ESP TR Sets

→	811	821	831	841	851	862	872	882
						861	871	881

Top View of ESP

Data to be collected by process sampling staff three times per test day (start, middle, end of sampling run).

Figure 4-57. Process Data Log No. 3: ESP

Time	Field	~~Bus~~ Date	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma
0932		4-26-93				
	811		Disconnected		(Get Readings on Front of	
	821		Disconnected		cabinet.	
	831		200		48	
	841		400		48	
	851		310		28	
	861		No Reading		30	
	862		430		30	
	871		No Reading		28	
	872		440		26	
	881		300		30	
	882		360		40	
Note:	Needle		Broken	on	secondary side	
			quested	on Readings		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

Data to be collected by process sampling staff three times per test day (start, middle, end of sampling run).

Figure 4-57. Process Data Log No. 3: ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/27-28/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
23:30	811		Variable 705-320	Var 25-42	Var. 28-51/24-53	94-150	STARHEIM
	821		315	65	43/53	292	
	831		220		56		
	841		400		62		
	851		250		54		
	861		N/A		46		
	862		400		66		
	871		N/A		56		
	872		450		60		
	881		290		52		
	882		360		66		
4/28/93							
0035	811		296	33	50/52	166	STARHEIM
	821		325	65	40/51	292	
	831		200		52		
	841		370		54		
	851		300		52		
	861		N/A		50		
	862		410		54		
	871		N/A		54		
	872		440		56		
	881		290		50		
	882		360		54		

* See drawing.

ESP TR Sets

→ 811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/27/83

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
0900	811		3[illegible]	34	[illegible]/[illegible]	[illegible]	[illegible]
	821			6[illegible]	[illegible]/50	242	
	831		[illegible]50		44		
	841		400		54		
	851		290		50		
	861		N/A		52		
	862		380		50		
	871		NA		43		
	872		450		54		
	881		300		48		
	882		360		52		
1100	811		174	16	52/53	110	[illegible]
	821		339	65	[illegible]/52	2[illegible]	
	831		150		44		
	841		400		56		
	851		2[illegible]		54		
	861		NA		50		
	862		380		52		
	871		NA		43		
	872		440		54		
	881		3[illegible]		43		
	882		360		54		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/27/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
21:35	811		variable 153-326	var. 26-54	var. 34-52/35-53	var. 110-173	[illegible]
	821		334	65	44/54	276	
	831		variable 0-210		38		
	841		410		60		
	851		280		54		
	861		N/A		54		
	862		410		56		
	871		N/A		56		
	872		450		60		
	881		290		52		
	882		360		54		
2230	811		207	42	50/52	118	[illegible]
	821		311	65	43/53	[illegible]	
	831		170-200		52		
	841		400		58		
	851		260		54		
	861		NA		54		
	862		360		52		
	871		NA		56		
	872		440		60		
	881		290		46		
	882		360		52		

* See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/27/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
[illegible]	811		326	36	[illegible]	[illegible]	[illegible]
	821		319	65	40/44	292	
	831		150		44		
	841		375		50		
	851		250		52		
	861		NA		48		
	862		390		54		
	871		NA		50		
	872		450		56		
	881		290		50		
	882		360		52		
20:25	811		300	35	40/41	variable 86-150	STARHEIM
	821		319	65	41/51	292	
	831		170		48		
	841		400		52		
	851		260		50		
	861		N/A		52		
	862		400		54		
	871		N/A		56		
	872		450		58		
	881		290		50		
	882		360		58		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/27/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1530	811		[illegible]	10	[illegible]	[illegible]	[illegible]
	821		325	[illegible]	[illegible]	300	
	831		210		50		
	841		420		56		
	851		300		56		
	861		NA		52		
	862		390		50		
	871		NA		54		
	872		450		48		
	881		30		52		
	882		360		53		
1630	811		325	39	50/51	130	[illegible]
	821		321	64	44/54	292	
	831		170		48		
	841		420		56		
	851		320		52		
	861		NA		50		
	862		415		58		
	871		NA		52		
	872		440		50		
	881		310		32		
	882		360		50		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/27/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1330	811		326	42	[illegible]	[illegible]	Hilborn
	821		[illegible]	[illegible]	[illegible]	292	
	831		[illegible]		52		
	841		400		54		
	851		300		52		
	861		NA		54		
	862		380		56		
	871		NA		52		
	872		450		56		
	881		300		48		
	882		360		54		
1445	811		Variable 187-325	Variable 19-46	50/52	158	STARHEIM
	821		328	65	43/52	292	
	831		200		52		
	841		400		56		
	851		310		54		
	861		N/A		50		
	862		390		58		
	871		NA		54		
	872		450		60		
	881		300		52		
	882		360		54		

* See drawing.

ESP TR Sets

→	811	821	831	841	851	862	872	882
						861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/27/93

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
17:37	811		variable 135 - 325	variable 27 - 45	variable 30-52/ 31 - 53	variable 142 - 215	STARHEIM
	821		316	65	44/54	292	
	831		variable 0 - 210		50		
	841		410		58		
	851		260		54		
	861		N/A		54		
	862		400		56		
	871		N/A		54		
	872		450		60		
	881		280		50		
	882		360		52		
1830	811		320	40	50/51	205	Hilburn
	821		319	65	42/53	292	
	831		200		50		
	841		390		58		
	851		270		54		
	861		NA		52		
	862		390		56		
	871		NA		56		
	872		440		60		
	881		280		46		
	882		370		52		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/27/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
11:30	811		variable 297	32	variable 18-54 / 19-54	35-110	STARHEIM
	821		330	65	44/54	292	
	831		170		48		
	841		400		60		
	851		300		54		
	861		N/A		54		
	862		370		56		
	871		N/A		54		
	872		440		60		
	881		300		38		
	882		360		54		
12:30							
	811		315	25	variable 19-52/20-52	39-141	STARHEIM
	821		319	65	43/53	292	
	831		100		46		
	841		360		56		
	851		250		48		
	861		N/A		52		
	862		380		54		
	871		N/A		52		
	872		450		58		
	881		300		52		
	882		360		54		

* See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: [illegible]

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
[illegible]	811		320	42	[illegible]/50	[illegible]	
	821		[illegible]	[illegible]5	[illegible]/[illegible]	[illegible]	
	831		200		54		
	841		400		58		
	851		320		56		
	861		NA		48		
	862		415		52		
	871		NA		52		
	872		440		56		
	881		300		50		
	882		370		56		
1030							STARHE[illegible]
	811		326	45	49/51	197	
	821		307	65	41/50	292	
	831		0-130		48		
	841		400		58		
	851		310		54		
	861		N/A		52		
	862		410		56		
	871		N/A		54		
	872		490		60		
	881		290		52		
	882		360		58		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: ______________

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1130	811		249	30	[illegible]	150	[illegible]
	821		317	23	[illegible]	[illegible]	
	831		100-150		46		
	841		360		52		
	851		250		48		
	861		NA		49		
	862		380		54		
	871		NA		50		
	872		440		56		
	881		290		52		
	882		360		54		
12:35	811		240	18	42/43	79	STANHOM
	821		297	45	38/47	variable 150	
	831		variable 0-110		32		
	841		340		54		
	851		190		38		
	861		N/A		46		
	862		300		50		
	871		N/A		56		
	872		410		52		
	881		290		48		
	882		360		54		

See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: [illegible]

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
13.55	811		variable 151-326	var. 16-37	var. 15-51/19-54	var. 47-110	STARHEIM
	821		[illegible]	[illegible]	42/52	[illegible]	
	831		variable 0-190	48	48		
	841		390		55		
	851		240		48		
	861		N/A		48		
	862		350		54		
	871		N/A		54		
	872		430		58		
	881		290		48		
	882		360		56		
							STARHEIM
14:25	811		variable 167-326	var. 17-37	49/50	110	
	821		329	65	42/52	276	
	831		190		42		
	841		370		52		
	851		270		52		
	861		N/A		42		
	862		380		52		
	871		N/A		52		
	872		440		60		
	881		280		50		
	882		360		54		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/28/93

Time 15	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
1530	811		[illegible]	22	50/51	[illegible]	Hilbrun
	821		324	65	43/33	220	
	831		150 to 200		46		
	841		410		54		
	851		260		46		
	861		NA		44		
	862		360		46		
	871		NA		50	-	
	872		435		54		
	881		290		50		
	882		360		52		
	811						
	821						
	831						
	841						
	851						
	861						
	862						
	871						
	872						
	881						
	882						

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/28/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
15							
1530	811		217	22	50/31	94	Hilborn
	821		324	65	43/33	229	
	831		150 to 200		46		
	841		410		54		
	851		260		46		
	861		NA		44		
	862		360		46		
	871		NA		50		
	872		435		54		
	881		290		50		
	882		360		52		
	811						
	821						
	831						
	841						
	851						
	861						
	862						
	871						
	872						
	881						
	882						

See drawing.

ESP TR Sets

→ 811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/29/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
[illegible]	811		variable [illegible]-32[illegible]	variable 33-[illegible]	49/[illegible]	variable [illegible]	STARH[illegible]
	821		[illegible]	[illegible]	[illegible]	[illegible]	
	831		190		50		
	841		360		56		
	851		260		52		
	861		N/A		50		
	862		390		[illegible]		
	871		N/A		52	–	
	872		440		58		
	881		290		52		
	882		350		52		
10:20	811		variable 174-326	var. 12-45	var. 27-52/29-53	var. 126-213	STARH[illegible]
	821		308	58	43/53	268	
	831		160		44		
	841		400		58		
	851		270		52		
	861		N/A		52		
	862		380		54		
	871		N/A		54		
	872		440		60		
	881		290		52		
	882		360		60		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/29/93

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
1100	811		variable 139-326	var. 11-43	var. 26-51/31-53	var. 55-156	STARHEIM
	821		335	58	44/55	[illegible]84	
	831		120		48		
	841		390		56		
	851		250		50		
	861		N/A		50		
	862		360		55		
	871		N/A		52		
	872		440		60		
	881		280		48		
	882		350		50		
1208							
	811		variable 222-320	var. 16-50	40/41	63	STARHEIM
	821		320	38	43/53	var. 57-[illegible]	
	831		[illegible]		38		
	841		340		54		
	851		200		48		
	861		N/A		52		
	862		350		52		
	871		N/A		54		
	872		430		58		
	881		280		48		
	882		350		52		

*See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/29/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1300	811		Variable 254-326	var. 26-47	41/43	63	Steinheim
	821		34	46	32/44	245	
	831		variable 0-110		38		
	841		380		58		
	851		190		44		
	861		N/A		48		
	862		380		60		
	871		N/A		54	–	
	872		440		60		
	881		290		46		
	882		350		54		
14:25	811		Variable 238-314	var. 15-28	44/45	var. 37-71	Steinheim
	821		variable 218-336	var. 26-114	41/51	var. 86-173	
	831		160		48		
	841		370		58		
	851		230		50		
	861		N/A		50		
	862		380		54		
	871		N/A		52		
	872		440		60		
	881		290		50		
	882		360		52		

*See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/29/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1600	811		271	22	51/[illegible]	35	Hillborn
	821		303	[illegible]	[illegible]/57	213	
	831		127		43		
	841		380		56		
	851		200		46		
	861		NA		50		
	862		360		56		
	871		NA		52		
	872		430		58		
	881		240		32		
	882		360		54		
1720	811		Variable 263-325	Var 19-35	44/45	110	[illegible]
	821		307	61	44/50	260	
	831		150		44		
	841		380		56		
	851		170		46		
	861		N/A		50		
	862		380		55		
	871		N/A		52		
	872		440		58		
	881		290		52		
	882		350		54		

*See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/29/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1830	811		284	21	[illegible]	2[illegible]	
	821		3[illegible]	6	[illegible]		
	831		125		46		
	841		360		52		
	851		180		44		
	861		N/A		50		
	862		375		52		
	871		NA		52		
	872		440		56		
	881		290		50		
	882		360		52		
19:45	811		Variable 220 – 318	Var. 18 – 41	Var. 29-51 / 25-50	Var. 43 – 115	STARHEIM
	821		300	62	44 / 54	200	
	831		Variable 0 – 190		40		
	841		380		56		
	851		210		52		
	861		N/A		50		
	862		370		54		
	871		N/A		54		
	872		440		58		
	881		290		52		
	882		360		56		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/24/[illegible]

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
2100	811		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	821		[illegible]	-	[illegible]	[illegible]	
	831		0-190		35		
	841		370		56		
	851		170		52		
	861		N/A		52		
	862		370		55		
	871		N/A		50		
	872		440		60		
	881		290		50		
	882		350		52		
	811						
	821						
	831						
	841						
	851						
	861						
	862						
	871						
	872						
	881						
	882						

* See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/30/02

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
0800	811		[illegible]	30	[illegible]	[illegible]	[illegible]
	821		[illegible]	[illegible]	[illegible]	[illegible]	
	831		175		42		
	841		380		50		
	851		200		44		
	861		NA		46		
	862		380		52		
	871		NA		50		
	872		440		54		
	881		290		50		
	882		360		54		
[illegible]	811		320	[illegible]	[illegible]	[illegible]	[illegible]
	821		[illegible]	[illegible]	[illegible]	300	
	831		150		46		
	841		370		56		
	851		200		46		
	861		NA		48		
	862		330		48		
	871		NA		50		
	872		440		[illegible]		
	881		290		52		
	882		350		50		

See drawing.

ESP TR Sets

→ 811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/31/92

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
10:30	811		326	33	[illegible]	[illegible]	Hillburn
	821		326	65	42/51	~~29~~ 2	
	831		100 to 150		40 - 43		
	841		400		54		
	851		160		46		
	861		NA		50		
	862		350		54		
	871		NA		54		
	872		400		56		
	881		300		52		
	882		360		54		
11 30							
	811		var. 137 - 32[illegible]	var. 18 - 35	var. [illegible]/ 26-52	var. [illegible]	STALHEIM
	821		330	62	[illegible]	[illegible]	
	831		var. 0-200		44		
	841		360		60		
	851		230		54		
	861		N/A		54		
	862		370		57		
	871		N/A		58		
	872		440		60		
	881		290		57		
	882		360		55		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/30/93

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
[illegible]	811		303	32	44/51	173	[illegible]
	821		335	35	45/52	292	
	831		[illegible]		44		
	841		400		56		
	851		220		44		
	861		[illegible]		48		
	862		400		54		
	871		NA		50		
	872		440		54		
	881		290		52		
	882		360		52		
1345	811		319	47	40/50	217	[illegible]
	821		309	55	40/50	292	
	831		200		50		
	841		390		56		
	851		270		52		
	861		NA		48		
	862		400		56		
	871		NA		52		
	872		450		56		
	881		290		52		
	882		380		56		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/[illegible]

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1415	811		Var. [illegible]	Var. 22-45	Var. [illegible]-51	Var. [illegible]	[illegible]
	821		[illegible]	65	[illegible]	[illegible]	
	831		200		50		
	841		390		68		
	851		230		48		
	861		N/A		48		
	862		380		55		
	871		N/A		52		
	872		390		58		
	881		290		52		
	882		360		54		
1530	811		300	33	30/52	110	Hilb[illegible]
	821		321	65	[illegible]/52	[illegible]	
	831		150 to 200		40 to 48		
	841		400		56		
	851		200		46		
	861		NA		50		
	862		400		56		
	871		NA		50		
	872		290		50		
	881		300		52		
	882		360		54		

See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 11/20/92

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1633	811		variable 118-32[illegible]	var 18-43	50/52	134	ST[illegible]
↓	821		3[illegible]	65	42/52	290	↓
	831		0-250		38		
	841		40		58		
	851		260		50		
	861		N/A		48		
	862		410		55		
	871		N/A		52	-	*
	872		440		54		
	881		290		52		
	882		360		56		
1755	811		variable 116-326	var 29-43	49/51	173	STARHEIL
↓	821		316	65	42/52	292	↓
	831		190		48		
	841		400		55		
	851		300		52		
	861		N/A		50		
	862		430		58		
	871		N/A		53		
	872		440		60		
	881		290		52		
	882		360		55		

* See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">→ 811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/30/0[illegible]

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1000	811		[illegible]	[illegible]	[illegible]	189	[illegible]
	821		319	65	41/50	[illegible]	
	831		100 to 200		44 to 48		
	841		380		54		
	851		190		48		
	861		NA		50		
	862		400		54		
	871		NA		50		
	872		440		54		
	881		290		52		
	882		360		54		
2000	811						Hilborn
	821						
	831		150		45		
	841		410		56		
	851		280		48		
	861		NA		48		
	862		420		52		
	871		NA		54		
	872		440		56		
	881		350		52		
	882		360		54		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 4/30/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
2100	811		302	41	49/51	181	[illegible]
	821		319	65	42/52	222	
	831		110		42		
	841		450		60		
	851		320		55		
	861		N/A		54		
	862		[illegible]		60		
	871		N/A		56	–	
	872		440		62		
	881		360		54		
	882		350		54		✓
	811						
	821						
	831						
	841						
	851						
	861						
	862						
	871						
	872						
	881						
	882						

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 5/1/93

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
0800	811		326	40	[illegible]	[illegible]	Hillborn
	821		320	65	[illegible]	[illegible]	
	831		150		46		
	841		400		54		
	851		330		48		
	861		NA		50		
	862		440		52		
	871		NA		52		
	872		~~370~~ 400		~~50~~ 56		
	881		360		50		
	882		360		50		
0920	811		325	48	49/51	205	STARHEIM
	821		311	65	42/52	292	
	831		110		42		
	841		400		55		
	851		330		54		
	861		N/A		48		
	862		440		58		
	871		N/A		52		
	872		440		58		
	881		360		50		
	882		350		50		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: [illegible]/11/[illegible]

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
[illegible]	811		320	47	50/52	166	[illegible]
	821		321	65	[illegible]/52	[illegible]	
	831		150		44		
	841		400		52		
	851		330		54		
	861		NA		50		
	862		440		56		
	871		NA		52		
	872		440		54		
	881		360		52		
	882		350		52		
[illegible]	811		326	41	50/5[illegible]	160	[illegible]
	821		32[illegible]	65	42/52	[illegible]	
	831		140		46		
	841		400		54		
	851		310		54		
	861		NA		48		
	862		[illegible]20		54		
	871		NA		54		
	872		440		58		
	881		350		52		
	882		360		54		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 5/1/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1230	811		326	35	41/42	185	STARHEIM
	821		[illegible]	65	42/53	292	
	831		120		44		
	841		400		66		
	851		320		58		
	861		N/A		50		
	862		430		58		
	871		N/A		52		
	872		440		62		
	881		360		50		
	882		350		54		
1330	811		326	30	44/47	110	[illegible]
	821		325	65	42/52	292	
	831		123		40		
	841		410		54		
	851		320		54		
	861		NA		50		
	862		440		54		
	871		NA		52		
	872		440		56		
	881		360		52		
	882		360		52		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: [illegible]

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
1500	811		variable 196-327	var 14-36	var 27-50/24-52	71-166	[illegible]
	821			330	65	44/54	
	831		130		45		
	841		400		56		
	851		320		55		
	861		N/A		50		
	862		410		58		
	871		N/A		56		
	872		440		60		
	881		360		54		
	882		350		56		
1600	811		325	30	50/[illegible]	34	[illegible]
	821		[illegible]	[illegible]	[illegible]	[illegible]	
	831		130		42		
	841		400		52		
	851		330		54		
	861		NA		50		
	862		430		54		
	871		NA		52		
	872		440		52		
	881		360		52		
	882		350		54		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 5/1/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1700	811		315	36	48/50	177	STARZEIN
	821		312	65	42/51	224	
	831		110		40		
	841		400		55		
	851		340		55		
	861		N/A		52		
	862		440		58		
	871		N/A		52		
	872		440		46		
	881		360		52		
	882		180		40		
							H:16m
1830	811						
	821						
	831		100		44		
	841		400		56		
	851		330		52		
	861		NA		52		
	862		440		56		
	871		NA		54		
	872		440		56		
	881		360		56		
	882		360		52		

* See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 5/1/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1930	811		300	49	49/51	213	STARHEIM
	821		318	65	42/52	324	
	831		130		44		
	841		400		56		
	851		320		52		
	861		N/A		50		
	862		420		55		
	871		N/A		52		
	872		440		55		
	881		360		50		
	882		350		55		
	811						
	821						
	831						
	841						
	851						
	861						
	862						
	871						
	872						
	881						
	882						

*See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 5/2/93

Time	Field	Bus	Primary Side Voltage, V	Primary Side Current, amps	Secondary Side Voltage, kV	Secondary Side Current, ma	Data Taker
0800	811		32[illegible]	71	48/50	[illegible]	Hilborn
	821		300	65	[illegible]	[illegible]	
	831		120		42		
	841		400		54		
	851		330		52		
	861		NA		50		
	862		400		54		
	871		ND		40		
	872		440		54		
	881		360		52		
	882		355		52		
1920	811		326	49	48/50	221	STARHEIM
	821		305	65	41/51	292	
	831		90		42		
	841		390		56		
	851		310		55		
	861		N/A		48		
	862		440		58		
	871		N/A		4[illegible]		
	872		440		46		
	881		360		[illegible]		
	882		350		5[illegible]		

See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 5/2/95

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1030	811		[illegible]	50	[illegible]	237	[illegible]
	821		[illegible]	[illegible]	[illegible]	[illegible]	
	831		100		40		
	841		390		54		
	851		360		52		
	861		NA		52		
	862		440		56		
	871		NA		54		
	872		440		52		
	881		360		54		
	882		360		52		
1130	811		[illegible]	[illegible]	12/44	122	[illegible]
	821		310	65	41/57	[illegible]	
	831		0		35		
	841		320		54		
	851		[illegible]		54		
	861		N/A		50		
	862		410		56		
	871		N/A		54		
	872		440		60		
	881		360		60		
	882		350		58		

* See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 5/2/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1230	811		[illegible]	[illegible]	[illegible]/50	[illegible]	[illegible]
	821		[illegible]	[illegible]	[illegible]	[illegible]	
	831		[illegible]		[illegible]		
	841		400		54		
	851		330		50		
	861		[illegible]		50		
	862		[illegible]		56		
	871		[illegible]		52		
	872		[illegible]		58		
	881		350		[illegible]		
✓	882		360		[illegible]		
[illegible]	811		326	52	49/51	181	[illegible]
	821		325	62	44/54	292	
	831		[illegible]20		42		
	841		410		58		
	851		330		[illegible]		
	861		N/A		48		
	862		430		62		
	871		N/A		54		
	872		440		60		
	881		360		56		
	882		350		56		

* See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 5/2/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1430	811		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	821		[illegible]	[illegible]	[illegible]/5	[illegible]	
	831		120		46		
	841		400		52		
	851		340		54		
	861		NA		52		
	862		435		56		
	871		NA		50		
	872		[illegible]		54		
	881		360		50		
	882		360		52		
[illegible]	811		325	58	48/50	[illegible]	[illegible]
	821		314	65	42/51	311	
	831		0 - 10		48		
	841		410		58		
	851		340		58		
	861		N/A		54		
	862		430		60		
	871		N/A		56		
	872		[illegible]		60		
	881		360		54		
	882		350		56		

* See drawing.

ESP TR Sets

<table>
<tr><td rowspan="2">811</td><td rowspan="2">821</td><td rowspan="2">831</td><td rowspan="2">841</td><td rowspan="2">851</td><td>862</td><td>872</td><td>882</td></tr>
<tr><td>861</td><td>871</td><td>881</td></tr>
</table>

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 5/2/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1630	811		326	50	[illegible]	213	[illegible]
	821		[illegible]	65	[illegible]	[illegible]	
	831		150		44		
	841		400		56		
	851		340		56		
	861		NA		52		
	862		440		56		
	871		NA		54		
	872		440		56		
	881		360		52		
	882		360		56		
1735	811		326	48	49/50	197	STARHEIM
	821		312	65	42/52	292	
	831		150		44		
	841		400		58		
	851		330		54		
	861		N/A		55		
	862		430		60		
	871		N/A		54		
	872		440		60		
	881		360		54		
	882		350		52		

* See drawing.

ESP TR Sets

811	821	831	841	851	862	872	882
					861	871	881

Top View of ESP

PROCESS DATA LOG NO. 3: ESP
(Take data four times per test day)

Date: 5/12/93

Time	Field	Bus	Primary Side		Secondary Side		Data Taker
			Voltage, V	Current, amps	Voltage, kV	Current, ma	
1800	811		326	44	44/46	[illegible]	[illegible]
	821		[illegible]	65	[illegible]	[illegible]	
	831		[illegible]70		48		
	841		400		56		
	851		310		52		
	861		N/A		54		
	862		440		60		
	871		N/A		54		
	872		440		60		
	881		360		56		
	882		350		58		
	811						
	821						
	831						
	841						
	851						
	861						
	862						
	871						
	872						
	881						
	882						

* See drawing.

ESP TR Sets

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</table>

Top View of ESP

SOOT BLOWING LOG
(DATA SHEET NO. 4)

DATA SHEET NO. 4: SOOT BLOWING LOG

Date: 4-26-93 #9 oil

Time Start	Time Stop	Soot Blowers Activated	Data Taker
0815	0818	#7 IK	R. Vecker
0822	0825	#3 IK	"
0830	0833	#4 IK	"
0850	0853	#6 IK	"
0946	0949	#6 IK	"
10:04	10:07	#3 IK	"
10:17	10:20	#7 IK	"
10:35	10:38	#3 IK	"
10:43	10:46	#4 IK	"
11:10	11:13	#6 IK	"
12:27	12:30	#6 IK	"
12:40	12:43	#3 IK	"
12:51	12:54	#4 IK	"
13:09	13:13	#6 IK	"
14:01	14:04	#3 IK	"
14:11	14:15	#4 IK	"
14:20	14:24	#6 IK	" 3 to 11 Shift
15:37	15:40	#3 IK	" J. TEKELY
15:48	15:57	#7 IK	"
16:08	16:13	#6 IK	"
1711	17:15	#3 IK	"
1717	1722	#7 IK	"
1730	1735	#6 IK	"
1742	1746	#4 IK	"

DATA SHEET NO. 4 : SOOT BLOWING LOG

Date: 4-26-93 #8 BLR.

Time Start	Time Stop	Soot Blowers Activated	Data Taker
1823	1827	#3 IK	J. TERELY 3-11 Shift
1827	1832	#7 IK	
1837	1841	#6 IK	
2013	2017	#3 IK	
2026	2033	#7 IK	
2041	2044	#6 IK	
2053	2057	#4 IK	
2142	2146	#3 IK	
2148	2153	#7 IK	
2200	2204	#3 IK	
2224	2229	#7 IK	
2234	2238	#6 IK	
23:13	23:18	#3 IK	C Newell 11-7 4-27-93
23:18	23:25	#4 IK	
23:27	23:30	#6 IK	
23:30	23:34	#7 IK	
01:12	01:15	#5 IK	
01:16	01:20	#6 IK	
01:20	01:29	#7 IK	
02:20	02:24	#3 IK	
02:38	02:42	#6 IK	

DATA SHEET NO. 4: SOOT BLOWING LOG

Date: 4-26-93 #9 Blr

Time		Water and Air Lanced #8 Blr ~~Soot Blowers Activated~~	Data Taker
Start	Stop		
0825	0830	Water Lanced #8 Blr west side 4th floor	R. Vicker
0835	0840	Air Lanced #8 Blr west side 3rd floor	"
10:10	10:17	Water Lanced #8 west side 4th floor	"
10:38	10:43	Water Lanced #8 Blr west side 4th floor	"
10:46	11:00	Air Lanced #8 Blr west side 3rd floor	"
11:00	11:10	Water Lanced #8 Blr. west side 4th floor	"
10:50	11:35	Dumped bottom ash	"
193[illegible]	2005	Dumped [illegible]	[illegible]

DATA SHEET NO. 4: SOOT BLOWING LOG

Date: 4-27-93

Time		Soot Blowers Activated	Data Taker
Start	Stop		
10:45	10:50	#3 I K	P. [illegible]
10:[illegible]	10:57	#7 I K	"
11:05	11:09	#6 I K	"
12:47	12:53	# 7 I K	"
13:16	13:20	#3 I K	"
13:20	13:24	#6 I K	"
13:25	13:[illegible]	#4 I K	
14:21	14:25	#6 I K	[illegible]
14:26	14:31	#7 I K	"
14:40	14:44	#3 I K	"
15:50	16:00	#3 I K	
16:00	16:04	#4 I K	
16:10	16:14	#6 I K	
16:48	16:51	3 I K	
18:13	18:16	3 I K	
18:17	18:20	6 I K	
18:38	18:41	7 I K	
19:[illegible]	19:09	4 I K	
19:[illegible]	19:[illegible]	3 I K	
19:49	19:52	3 I K	
19:53	19:56	7 I K	
21:48	21:51	3 I K	
21:52	21:55	4 I K	
22:32	22:34	3 I K	

DATA SHEET NO. 4: SOOT BLOWING LOG

Date: 4-28-93

Time		Soot Blowers Activated	Data Taker
Start	Stop		
00:06	00:10	#4 IK	Budrevich
00:14	00:17	#6 IK	Budrevich

DATA SHEET NO. 4: SOOT BLOWING LOG

Date: 4-27-93

Time		Air Force and water Lanced #8 Blr ~~Soot Blowers Activated~~	Data Taker
Start	Stop		
11:12	12:0K	Dumping Bottom ashes #8 Blr	R. Vickers
12:18	12:48	#84 mill	"
10[illegible]	10[illegible]	Dumping [illegible]	[illegible]

Date: __

Time	
Start	S[illegible]
083[illegible]	0[illegible]
[illegible]	[illegible]
0934	0[illegible]

DATA SHEET NO. 4: SOOT BLOWING LOG

Date: 4-28-93

Time		Loss of mill or Air Lancing and Water Lancing #81 ~~Soot Blowers Activated~~	Data Taker
Start	Stop		
10:47	11:30	Dumping bottom ash in #8 B [illegible]	[illegible]
11:10	11:56	Lost 84 mill coal chute plugged	"
12:05	12:30	Lost 84 Mill coal chute plugged	"
12:23	13:00	Lost 81 mill coal chute plugged	"
12:40	13:08	Lost 84 mill coal chute plugged	"
15:33		LOST #81 MILL COAL CHUTE PLUGGED	[illegible]

DATA SHEET NO. 4 : SOOT BLOWING LOG

Date: [illegible]-1-92

Time Start	Time Stop	Air Lancing + Water Lancing, Dumping bottom ash ~~Soot Blowers Activated~~	Data Taker
10:42	11:08	Lost 83 mill, coal feeder sheared [illegible]	[illegible]
11:10	12:05	Dumping bottom ash = 9 [illegible]	[illegible]
17:37	18:5[illegible]	Lost [illegible] mill, coal feeder sheared [illegible]	R. Vicker
18:40	19:30	Dumping bottom ash = 8 [illegible]	R Vicker

DATA SHEET NO. 4: SOOT BLOWING LOG

Date: 5 [illegible]

Time Start	Time Stop	Soot Blowers Activated	Data Taker
08:52	08:56	IK6	[illegible]
09:14	09:18	IK3	
[illegible]	1004	1K 7	
[illegible]		[illegible]	
1210	1214	1K [illegible]	
12[illegible]	1219	IK #3	
12[illegible]	[illegible]	IK #[illegible]	
13:1[illegible]	13:22	I[illegible] #7	
13:50	13:54	IK #3	
1[illegible]	[illegible]9	IK [illegible]	
1445		1K #6	[illegible]
		1K-3 Air lake east end Floor	
		1K-7	
15:40	15:44	1K-7	
15:46	15:51	1K-6	
16:31	16:36	1K-3	
16:36	16:40	1K-7	
16:57	17:01	1K-3	
17:04	17:09	1K-7	
17:15	17:20	1K-6	
17:55	[illegible]	1K-6	
18:32		1K-3	

DATA SHEET NO. 4: SOOT BLOWING LOG

Date: [illegible]

Time Start	Time Stop	Soot Blowers Activated	Data Taker
0824	08-[illegible]	83 mill [illegible]	R. Vick[illegible]
11:[illegible]		[illegible] [illegible] [illegible] [illegible] [illegible])	"
11:42	12:05	[illegible] #8 [illegible] [illegible]	"
1-[illegible]	[illegible]10	Air [illegible] [illegible] 3rd [illegible] East & West [illegible]	[illegible]

PYRITE DUMPING DATA

FORM 32 (REV. 2-77)
ID NO 5800390

OHIO EDISON COMPANY

INTER-OFFICE MEMORANDUM

DATE 4-29-93

TO whom it may concern LOCATION SNRB

FROM Shift Supv LOCATION Oper

SUBJECT 8 BLR PULVS - LAST PYRITE DUMP TIMES

81 - 05.02

82 - 05.00

83 - 04:59

84 - 04:58

85 - 04:57

4W179

SHIFT (8-4) / 4-12 / 12-8 DATE: 4/1/92 T.A.Geer

#5 UNIT PYRITE SURVEY / MILL STATUS REPORT

PULV. NO.	TIME	PYRITE TYPE	DID MILL EMPTY YES /NO	NUMBER OF DUMPS ATTEMPTED	SEAL AIR LOW / HIGH	MILL OUTLET TEMP.	P.A.FAN STATUS, FEEDER STATUS, & MILL STATUS LIST SPECIAL NOTES ON OIL, VIBRATION, LEAKS,ECT.
#81							WEIGHT:
	07:42	Coal	Yes	1½	Low		110
	10:45	Fine	Yes	1	Low		117.0
	12:56	Fine	Yes	1	Low		165.5
#82	08:09	Fine Coal	Yes	1	Low		WEIGHT:
	10:48	Fine Coal	Yes	1	Low		54.5
	13:00	Fine Coal	Yes	1	Low		44.0
							56.5
#83	08:14	Coarse	No-Yes	1½	Low		WEIGHT:
	10:50	Coarse	Yes	1	Low		105.5
	13:04	Coarse	Yes		Low		121.0
							137.0
#84	08:20	Coarse	No-Yes	2	Low		WEIGHT:
	10:56	Coarse	Yes	1	Low		242.5
	13:07	Coarse	Yes	1	Low		146.5
							166.0
#85	08:27	Rock	Yes	1	Low		WEIGHT:
	10:54	Rock	Yes	1	Low		32.5
	13:10	Rock	Yes	1	Low		16.5
							13.0

SHIFT 8-4 / 4-12 / 12-8

DATE: 4-29-93

4/1/92 T.A.Geer

#5 UNIT PYRITE SURVEY / MILL STATUS REPORT

PULV. NO.	TIME	PYRITE TYPE	DID MILL EMPTY YES /NO	NUMBER OF DUMPS ATTEMPTED	SEAL AIR LOW / HIGH	MILL OUTLET TEMP.	P.A.FAN STATUS, FEEDER STATUS, & MILL STATUS LIST SPECIAL NOTES ON OIL, VIBRATION, LEAKS,ECT.
#81							WEIGHT:
	07:42	Coal	Yes	1 1/4	Low		110"
	10:45	Fine	Yes	1	Low		117.0 — 282.5 lb = 53.98 lb/hr
	12:56	Fine	Yes	1	Low		165.5 — 5hr;14min
#82	0809	Fine Coal	Yes	1	Low		WEIGHT:
	10:48	Fine Coal	Yes	1	Low		54.5
	13:00	Fine Coal	Yes	1	Low		44.0 — 100.5 lb = 20.72 lb/hr
							56.5 — 4hr;51min
#83	0814	Coarse	No-Yes	1 1/4	Low		WEIGHT:
	10:50	Coarse	Yes	1	Low		105.5
	13:04	Coarse	Yes	1	Low		121.0 — 258.0 lb = 53.38 lb/hr
							137.0 — 4hr;50min
#84	0820	Coarse	No-Yes	2	Low		WEIGHT:
	10:56	Coarse	Yes	1	Low		242.5
	13:07	Coarse	Yes	1	Low		146.5 — 312.5 lb = 65.33 lb/hr
							166.0 — 4hr;47min
#85	0827	Rock	Yes	1	Low		WEIGHT:
	10:54	Rock	Yes	1	Low		32.5
	13:10	Rock	Yes	1	Low		16.5 — 49.5 lb = 10.49 lb/hr
							13.0 — 4hr;43min

203.9 lb/hr

SHIFT 8-4 / 4-12 / 12-8

DATE: 7-20-12

4/1/92 T.A.Geer

#5 UNIT PYRITE SURVEY / MILL STATUS REPORT

PULV. NO.	TIME	PYRITE TYPE	DID MILL EMPTY YES /NO	NUMBER OF DUMPS ATTEMPTED	SEAL AIR LOW / HIGH	MILL OUTLET TEMP.	P.A.FAN STATUS, FEEDER STATUS, & MILL STATUS LIST SPECIAL NOTES ON OIL, VIBRATION, LEAKS, ECT.
#81	0727	Powder	YES	1	High		WEIGHT:
	0953				Low		120.0
	11:00	MIXED			Low		116.0 } 507.5 lb in 5hr; 49 min
	13:16				High		14[illegible].5 ~~98.1~~ lb/hr 87.25
							227.0
#82	0733	Powder	yes	1	Low		WEIGHT: Front Cover Leaking
	0953						67.5 14.75 lb/hr Primary Air-Blowing
	11:00	Powder	YES				25.0 86.8 lb 5h;53m IN FACE
	13:16						27.8
							34.0 1300-Broken Coupling
#83	0718	Rock	YES	1	Low		WEIGHT:
	0958						78.5 Door Gasket leaks
	11:00	Rock	Yes				58.0
	13:16						89.0 } 302.5 lb = 50.70 lb/hr
							155.5 5h;58m
#84	0705	Powder	NO	3	High		WEIGHT:
	0904				Low		118.5
	11:00	Powder		1	High		126.5
	13:16				High		53.0 } 202.0 lb = 32.67 lb/hr
							26.5 6hrs; 11m
#85	0715	Rock	Yes	1	Low		WEIGHT:
	0900						28.5
	13:16						No DUMP } 31.5 lb = 5.24 lb/hr
							No DUMP 6hrs; 1mm
							31.5

12/8 Shift LAST Dump @ 05:10

190.61 lb/hr

ESP HOPPER DUMPING DATA

[redacted]

ESP Dump 2-4 pm

		min	Hopper
1:55pm Start	Row 3	1-0- 1:10	43
		2 1:10 - 2:25	33
		3 2:25 - 3:57	23
		4 3:57 - 4:36	13
	Row 2	1- 4:36 - 5:59	42
		2- 5:59 - 7:47	32
		3- 7:47 - 9:34	22
		4- 9:34 - 11:11 add 20 sec .. restart	12
		Break in action!	
	Row 1	1 - 0 - 5:04 10 sec interruption	41
		2 - 5:04 - 9:44	31
		3 - 9:44 - 18:51	21
		4 - 18:51 - 23:39	11
	Row 3	1- 23:39 - 24:13	
		2- 24:13 - 24:41	
		3- 24:41 - 25:10	
		4- 25:10 - 25:34	
	Row 2	1- 25:34 - 26:11	
		2- 26:11 - 26:59	
		3- 26:59 - 27:37	
		4- 27:37 - 28:11	

~~4/26/93~~

Row 1 1- 28:10 - 29:28
2- 29:28 - 30:27 0 - :26
3- ~~30:27~~ - shutdown :26 - 2:16
4 ~~2:16~~ -
2:32 - 3:45

843	Row 3	1	add 15 sec 0 - 0:08
833		2	0:22 - 0:50
823		3	1:06 - 1:36
813		4	1:51 - 2:15
842	Row 2	1	2:33 - 3:12
832		2	3:26 - 4:08
822		3	4:22 - 4:59
812		4	5:17 - 5:53
841	Row 3	1	6:12 - 7:26
831		2	7:38 - 8:30
821		3	8:44 - 9:43
811		4	10:00 - 10:49

Time 3:03

I-CHEM

CLIENT/SOURCE	☑ GRAB ☐ COMPOSITE OTHER:
SITE NAME 11	DATE 4/26/93
SAMPLE # 11-3-2e	TIME 1700
ANALYSIS Clinked up	PRESERVATIVE COLL. BY RS

TJK ~~9/26/03~~ 6 ; pm approx

Start 18:02	Row 3	0 - 31 sec	43
		31 - 64 sec	33
		~~[illegible]~~ 64 sec - 1:31	23
		1:31 - 2:03	13
	row 2	2:20 - 3:37 (~~2:03~~)	42
		3:37 - 4:57	32
		4:57 - 6:08	22
		6:08 - 7:12	12
	row 1	7:12 - 9:43	41
		9:43 - 11:59	31
		11:59 - 14:33	21
		14:33 - 16:57	11
	row 3 again	0 - 31 sec	43
		31 sec - 1:01	33
		1:01 - 1:29	23
		1:29 - 1:45	13
	row 2	1:45 - 2:28	42
		2:28 - 3:17	32
	the system skipped this one!	~~3:17~~ -	22
		3:17 - 3:34	12

tim real-ved o these, real-to

(over)

TJK ~~[illegible]~~ 3

row 1	3:34 - 4:45	41
	4:45 - 5:47	31
system jumped here	~~[illegible]~~ 6:07 - 7:20	21
	7:20 - 8:15	11

d clock time : 18:30

Run Start Time = 10:15am

~~4/27/93~~ ESP Dump Rows 1,2,3

1701 hrs	Row 3	0 - 1:16	43
		1:16 - 2:46	33
		2:46 - 4:18 - 4:52	23 redo 2nd +
		4:52 - 6:08	13
			Lag time
	Row 2	6:27 - 8:28	42
		8:40 - 11:05	32
		11:08 - 13:35	22
		13:50 - 15:53	12
	Row 1	16:08 - 21:32	41
		21:39 - 26:40	31
		26:50 - 34:12	21
		34:22 - 38:48	11
	Row 3	38:52 - 39:28	43
		39:39 - 40:37	33
		40:52 - 41:41	23
		41:55 - ~~42:33~~ 43:00	13
	Row 2	43:18 - 44:06	42
		Skipped	32
		44:06 - 45:11	22
		45:27 - 46:30	12

~~[illegible]~~

		Hopper#
Row 1	46:49 - 48:29	41
	48:39 - 50:25	31
	50:37 - 52:08	21
	52:21 - 53:45	11

---

missed - 1st collection at Location #9 - plugged
got 2nd collection late (Ohio E. unplugged)

4:00 collection from ESP - problems with not enough material from row 3

4/28/93 Run Starts =
Rows 1+2

			Hopper#
10:37	~~[illegible]~~	0 - 2:20	42
	Row 2	2:34 - 4:40	32
		4:54 - 6:56	22
		7:07 - 9:12	12
	Row 1	9:26 - 15:45	41
		15:49 - 22:24	31
		22:38 - 32:10	21
		32:24 - 39:41	11

~~4/29/93~~

ESP Dump 1 + 2

		Clock Time		Hopper
2:31	Row 2	2:31 - 2:35	(4 min)	42
		2:35 - 2:40	(5 min)	32
		2:40 - 2:44	(4 min)	22
		2:44 -	( )	12

Row 1

Shutdown (low on H_2O)

9-~~B~~ 1510

ESP Dump — 1700 hrs

8 × 250ml = 2000 g
12 × 250ml = 3000 g
5000 g

8A
8B
Pyrite
1800 hrs

4/29/93

8A
8B
Pyrite
9A
collected 1930 hrs

4/30/93

Dump of ESP Row 1+2 7am - 8am

pling
inter
Sampling Started = 8:15am

)817

Hours Into Test

	8:15 → 0	1	2	3	4	5	6	7	8	9	10	11	12
			10:00	11:30	12:30	2:00		3:15					
tom Ash (8)		XX DSS →		XX DSS →		XX DSS →		XX DSS					
nomizer (9)		XX DSS →		XX DSS		XX → DSS		XX DSS					
te Rejects		X DSS →		X DSS →		X DSS →		X DSS					
P (11)			1-2 RNS X		1-2 RNS X →		1-2 RNS X	~~O dump (1-2) timed~~					

ESP Dump 1+2 last Dump → 1630 hrs
* No timed dump - system already dumped ahead of time

out down 0942 back up 1015

5/1/93

Dump of ESP Rows 1+2 7-8 am

Sampling Started = 0835

Hours into test

8:35 →	0	1	2 (10:30)	3	4 (12:30)	5	6 (2:30)	7 (3:30)	8 (4:30)	9 (5:30)
Bottom Ash (8)			xx DSS		xx DSP		xx DSS →		xx DSS →	
Economizer (9)			xx DSS		~~xx~~ water Pressure Problem		xx DSS →		xx DSS →	
~~Pyrite Rejects~~			~~x~~		~~x~~		~~x~~		~~x~~	
ESP (11)				1-2 X DSP → 12:30			1-2 DSS X → 4:00		1-2 X → 6:	

Start 1251 ESP Time Dump Rows 1+2

	min	Hopper #
Row 2	0- 6:13	42
	6:22 - 11:47	32
	11:53 - 16:58	22
	17:08 - 21:~~24~~ 55	12
Row 1	22:08 - 42:46	41

Water Problems

5/2/93

Start Run → 8:30 am

Hour into test

	0	1	2	3	4
8:30 →					
ttom Ash		X →	~~X~~	X	
onomizer		X →	~~X~~	X	
SP		X →	~~X~~	X	

# of samples

8
6
1
4
4
5
8 36
12
4 16
5 13
8
3 15
12
8 12
4
6
7
3 19
3
4
12 20
4
2 6
4

137

12 18
6
11 14
3
12
6 30
12
3
5 10
2
4 15
11
12 23
11
7
8 25
10
2
5 19
12

154

8
1 13
4
6 14
8
2
4 18
12
12
4 28
12
10
1 16
2
3
5 10
5
12 15
3

114

405 TOTAL SAMPLES
2
407

~~• Mike – internal [redacted] communications.~~ ✓

B/R

~~4/26~~

6 am dump

@ 9:55

		4	3	2	1
	row 2	72 sec	110 sec	83 sec	84 sec
Hopper	row 1	261 sec	260 sec	394 sec	210 sec

TIME TO DUMP

COAL FEED DATA

#8 BLR

DAY	TONAGE		FINISH
MON	1315.6 → START		~~F~~ 13:35
TUES	1286.7		
WED	1584.8		
THURS	1478.1		
FRI	1560.4		
SAT	1583.4		
SUN	1579.5		13:20
	9072.9 TONS /		119.75 hrs

= 75.765 TONS/hr

APPENDIX G

QAPP DEVIATIONS

EER CORPORATION MEMO

TO: Karen Riggs

FROM: Jerry Lewis

DATE: April 25, 1993

SUBJECT: Deviations from SNRB QAPP

CC: Distribution to all team members

ITEM 1: A revised Figure 4-60 is enclosed. This more accurately represents the process sampling that will take place on a daily basis.

ITEM 2: The thief sampler used for sample collection at Location 11 will be electrically grounded when sampling.

ITEM 3: Testing will be discontinued if Boiler #8 load fluctuates greater than ±5 MW. Fluctuations of more than ±5 MW will represent unsteady operation. If one of five mills fails, the test will be suspended. Plant personnel will assess the time required to restore the mill to service. If the mill can be restored in a short period of time, the test will be continued once the mill has been returned to service and the system has stabilized. If the mill cannot be quickly restored, the test will be continued with 4 mills in operation once the system has stabilized.

ITEM 4: Sample Location 12 has 6 ports instead of the previously shown 10 ports. A revised Figure 4-14 is enclosed.

ITEM 5: Two of the 5 ports at Location 10 (west duct) are inaccessible. The sample matrix will be modified to accommodate the changes in ports. An 8 x 3 matrix will be conducted on the 3 ports on the west duct and a 6 x 4 matrix will be conducted on the east duct. A revised Figure 4-12 is enclosed.

ITEM 6: A revised Figure 4-55, Day 2 Sampling Schedule, is enclosed.

ITEM 7: Formaldehyde wipe test will be performed in the recovery trailer to detect background contamination.

TEM 8: Location ten (10) orginally indicated a centroid sample matrix of 33 total points to be sampled. Due to the matrix modifications deemed necessary as indicated in ITEM 5, each duct will be sampled at 24 points, making a total of 48 total sample points instead of the proposed 33 points. Increasing the proposed sample time to 2 hours instead of 1.37 hours.

ITEM 9: A coal sample in a single container will be provided for ultimate, proximate, and higher heating value rather than the three (3) separate containers as indicated in Figure 4-50 of the QAPP. A revised figure will not be enclosed but will be provided in the final report.

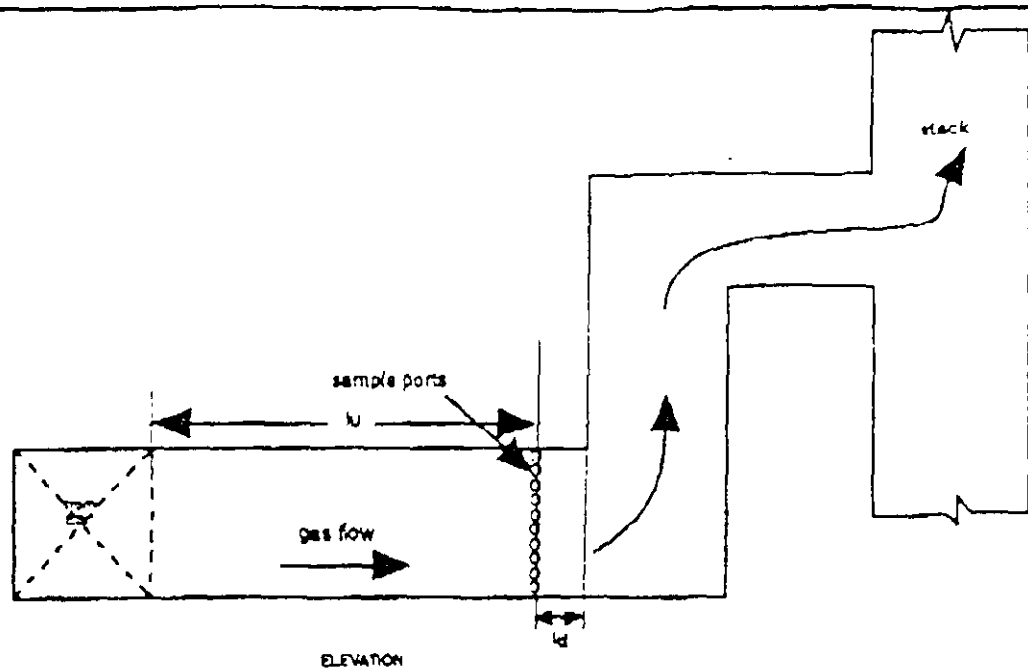
ITEM 10: An ash sample in a single container will be provided for loss on ignition and unburned carbon rather than the two (2) separate containers as indicated in Figures 4-52, 4-53, and 4-54 of the QAPP. Revised figures will not be enclosed but will be provided in the final report.

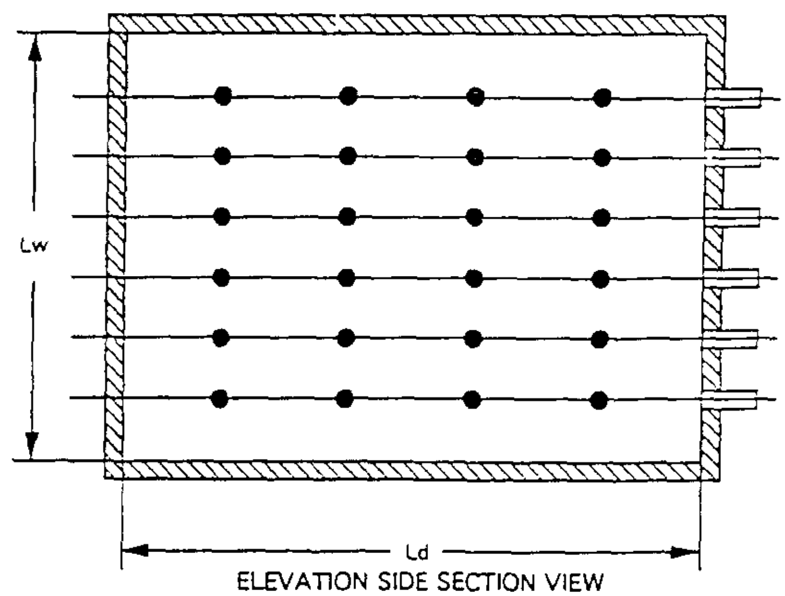
ITEM 11: Due to the high concentrations of SO2 present in all flue gas locations, and in an effort to prevent damage to EER's sampling equipment. An extra impinger containing H2O2 located prior to the silica gel impinger will be used to knock out excessive SO2 levels in all sampling trains except for the metals. Approvals have been obtained from each methods primary contact at EPA's EMB.

Location	Test Day	Hours Into Test													Comments
		0	1	2	3	4	5	6	7	8	9	10	11	12	
Coal Feed (Loc. 1)	Day 1	Mill 1		Mill 2			Mill 3			Mill 4			Mill 5		Daily Samples will be composited
	Day 2	Mill 1		Mill 2			Mill 3			Mill 4			Mill 5		Daily Samples will be composited
Sorbent Feed (Loc. 3)	Day 1	X												X	Pre and Post grabs composited
	Day 2	X												X	Pre and Post grabs composited
SNRB Solids (Loc. 6)	Day 1		1	2	3	4	5	1	2	3	4	5			Number designate hoppers, daily composite
	Day 2		1	2	3	4	5	1	2	3	4	5			Number designate hoppers, daily composite
Bottom Ash (Loc. 8)	Day 1		X			X			X			X			Daily samples will be composited
	Day 2		X			X			X			X			Daily Samples will be composited
Economizer (Loc. 9)	Day 1		X			X			X			X			Daily Samples will be composited
	Day 2		X			X			X			X			Daily Samples will be composited
Collected Ash (Loc. 11) *	Day 1		A				B				C				16 hoppers sampled, daily composite
	Day 2		A				B				C				16 hoppers sampled, daily composite
Pyrite Rejects	Day 1														Daily Samples composited
	Day 2		X						X						Daily Samples composited

Figure 4-60R. Process Sampling Schedule

* A - 4 hoppers in each of row 1
B - 4 hoppers in each of rows 1, 2, and 3
C - 4 hoppers in each of rows 1, 2, and 4





Revised 4/23/93

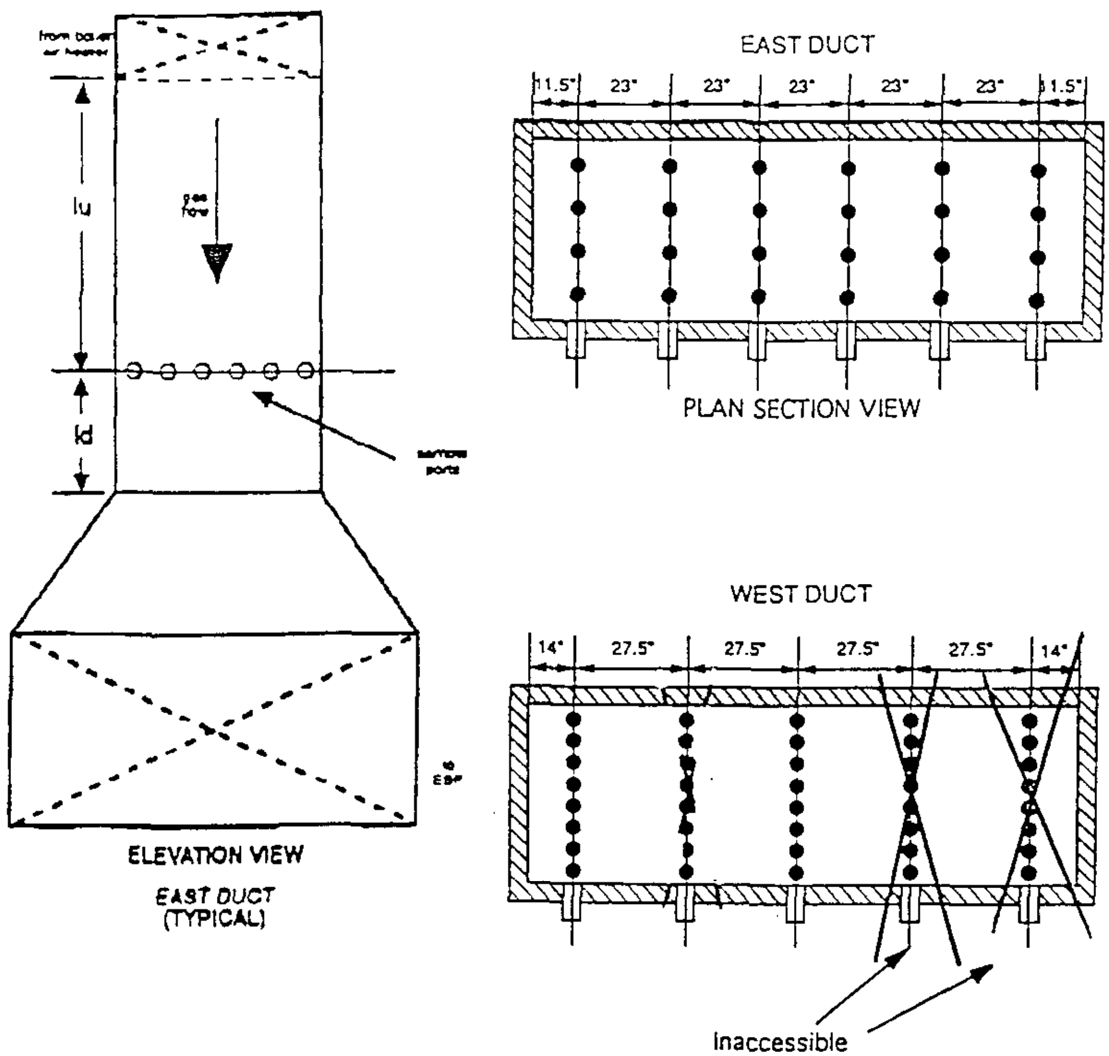
Inside width (Lw) 11'6" inches
Inside depth (Ld) 11'6" inches
Distance to upstream disturbance (lu) 336 inches
Distance to downstream disturbance (ld 52 inches
Sample port inside diameter (Dsp) 6.5 inches
Sample port length*(lsp) 22 inches

*Inches from near wall to end of coupling

Traverse Point Location

Point No.	Distance from inside Wall
1,5,9,13,17,21	27.6
2,6,10,14,18,22	55.2
3,7,11,15,19,23	82.8
4,8,12,16,20,24	110.4

Figure 4-14. Sampling Location 12 - ESP Outlet.



Revised 4/23/93

Inside width (Lw) 138 inches
Inside depth (Ld) 69 inches
Distance to upstream disturbance (lu) 300 inches
Distance to downstream disturbance (ld) 117 inches
Sample port inside diameter (Dsp) 4 inches
Sample port length*(lsp) 24 inches

*inches from near wall to end of coupling

Traverse Point Location

Point No.	Distance from inside wall
EAST DUCT	
1,5,9,13,17,21	8.625
2,6,10,14,18,22	25.875
3,7,11,15,19,23	42.125
4,8,12,16,20,24	59.375
WEST DUCT	
1,9,17	4.3125
2,10,18	12.9375
3,11,19	21.5625
4,12,20	30.1875
5,13,21	38.8125
6,14,22	47.4375
7,15,23	56.0625
8,15,24	64.6875

Figure 4-12. Sampling Location 10 - ESP Inlet.

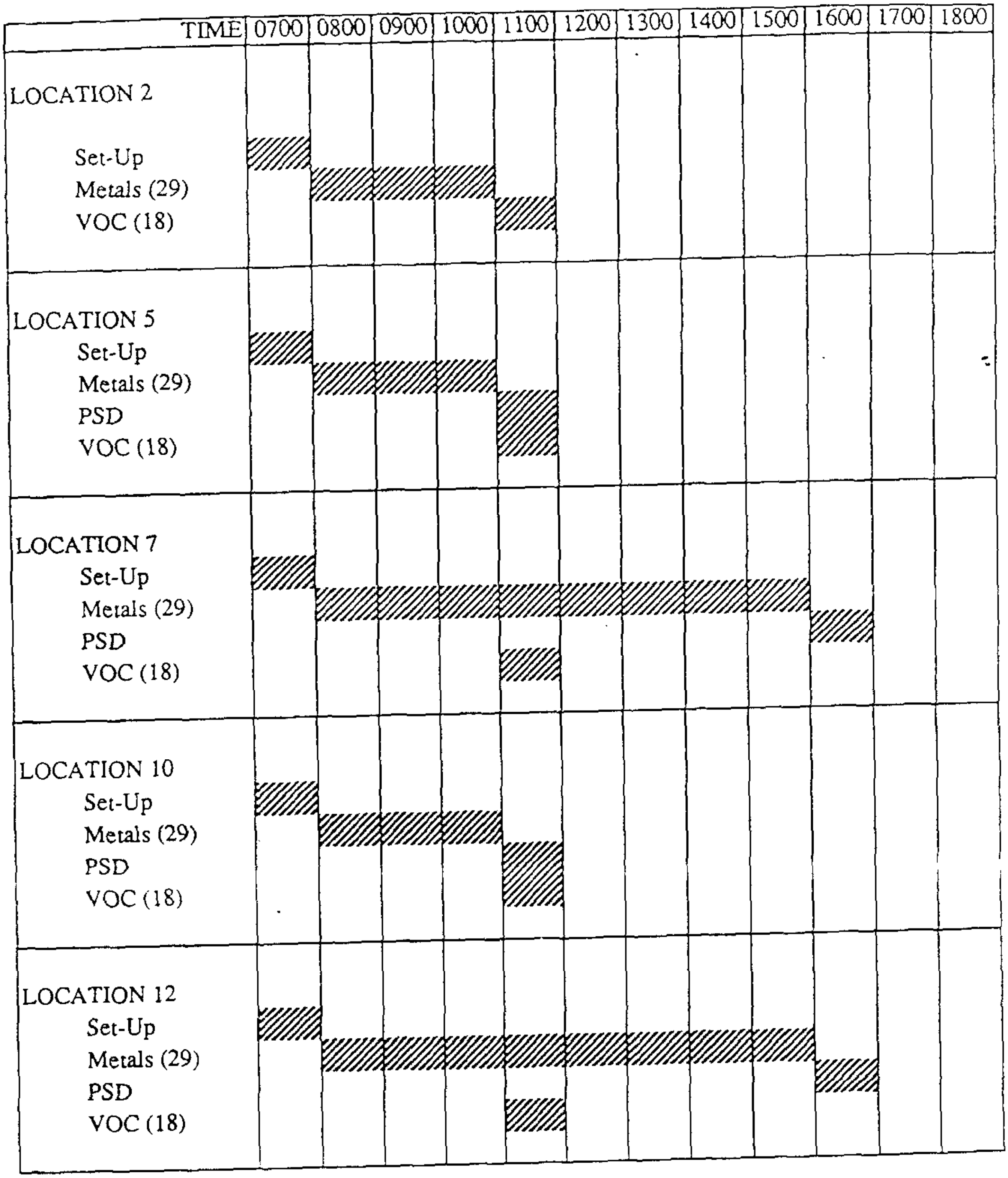


Figure 4-55. Day 2 sampling schedule.

MEMORANDUM

Date: April 30, 1993

To: B&W SNRB Air Toxics Monitoring Project Staff

From: Karen Riggs KR

Subject: QAPP Deviation - Page 3-3

The target total sample time and total sample volume for the Method 18 (Tedlar Bag) in Table 3-2 on Page 3-3 of the QAPP has been changed. The revised target values are 30 min for the total sample time and 15 L for the total sample volume.

Distribution:

G. Sverdrup
G. England (EER)
J. Lewis (EER)
K. Riggs ✓
M. Schrock
B. Baytos
J. Chuang
M. Holdren
G. Meyer
D. Oyler
D. Smith
D. Smith
R. Barrett
J. Czuczwa (B&W)

MEMORANDUM

Date: April 30, 1993

To: B&W SNRB Air Toxics Monitoring Project Staff

From: Karen Riggs

Subject: QAPP Deviation - Page 5-9 (Table 5-1)

The storage temperature requirement of 4°C for solid process samples collected for trace element, radionuclide, chloride/fluoride, unburned carbon, heating value, ultimate/proximate, and loss on ignition analyses has been eliminated. These samples can be stored at 4°C if desired, or at ambient temperature.

Distribution:

G. Sverdrup
G. England (EER)
J. Lewis (EER)
K. Riggs
M. Schrock
B. Baytos
J. Chuang
M. Holdren
G. Meyer
D. Oyler
D. Smith
D. Smith
R. Barrett
J. Czuczwa (B&W)

MEMORANDUM

Date: May 3, 1993

To: B&W SNRB Air Toxics Monitoring Project Staff

From: Karen Riggs

Subject: QAPP Deviation - Page 2-12

The first sentence in Section 2.3.2 Laboratory Sample Custodian is replaced with the following "The Laboratory Sample Custodian, Mr. David Oyler **or a designated alternate,** will assume responsibility for sample custody upon receipt of samples at Battelle."

Distribution:

G. Sverdrup
G. England (EER)
K. Riggs
M. Schrock
B. Baytos
J. Chuang
M. Holdren
G. Meyer
D. Oyler
Deb Smith
J. Tabor
R. Barrett
J. Czuczwa (B&W)

MEMORANDUM

Date: May 27, 1993

To: B&W SNRB Air Toxics Monitoring Project Staff

From: Karen Riggs

Subject: QAPP Deviation - Page 4-74

The following sentence should be added to **Section 4.3.2** **Solid Process Sampling**: "All process samples will be composited after completion of field sampling by Commercial Testing & Engineering Co."

Distribution:

G. Sverdrup
G. England (EER)
K. Riggs
M. Schrock
J. Chuang
M. Holdren
G. Meyer
D. Oyler
Deb Smith
J. Tabor
R. Barrett
J. Czuczwa (B&W)

MEMORANDUM

Date: June 14, 1993

From: Karen Riggs KR

To: B&W SNRB Air Toxics Monitoring Project Staff

Subject: QAPP Deviation - Page 5-9

Due to the transfer of compositing from the field to Commercial Testing & Engineering, Co., the holding times for various analyses have been changed as follows:

Trace Elements - 12 weeks
Higher Heating Value - 12 weeks
Proximate/Ultimate Analysis - 12 weeks
Cl,F - 12 weeks
Radionuclides - 16 weeks
Unburned Carbon - 12 weeks
Loss on Ignition - 12 weeks.

The analytes affected by this change in holding times are stable and data quality will not be impacted as a result of this change.

Distribution:

G. Sverdrup
G. England (EER)
K. Riggs
M. Schrock
J. Chuang
M. Holdren
G. Meyer
D. Oyler
Deb Smith
J. Tabor
R. Barrett
J. Czuczwa (B&W)

MEMORANDUM

Date: June 18, 1993

From: Karen Riggs KR

To: B&W SNRB Air Toxics Monitoring Project Staff

Subject: QAPP Deviation - Page 7-3

The 4th impinger rinse, permaganate impinger catch, and 8N HCl rinse of the permaganate impingers (labelled as 4A, 4B, and 4C on EER chain-of-custody sheets) should be combined for analysis of Hg rather than conducting separate Hg analyses of these sample components.

Distribution:

G. Sverdrup
G. England (EER)
K. Riggs
M. Schrock
S. Liao
J. Chuang
M. Holdren
G. Meyer
D. Oyler
Deb Smith
J. Tabor
R. Barrett
J. Czuczwa (B&W)

APPENDIX H

FIELD SAMPLING AUDIT REPORT

REPORT ON OFFICIAL TRAVEL

To: K. Riggs | Date: July 11, 1993
By: W.C. Baytos | Project Number: G 2802-4300
Left Columbus: April 26, 1993 | *Returned:* April 29, 1993

Trip to: Ohio Edison Company's R.E. Burger Electric Generating Plant
Shadyside, Ohio

Purpose of Trip: To conduct an On-site Audit of the Field Sampling Activities being Performed by Energy and Environmental Research Corporation (EER).

Persons Interviewed:
Mr. Jerry Lewis, Field Manager for EER and his field sampling crew

Reference Document:
Quality Assurance Project Plan on SNRB Air Toxic Monitoring to Babcock & Wilcox Company, Dated April 20, 1993
Prepared by Battelle, Columbus, Ohio

Essential details of trip and summary of results obtained.

Essentially, the sampling tasks done by the EER field team for the simultaneous collection of flue gas samples from the five locations, were performed according to the Test Protocols described in the Quality Assurance Project Plan. No major problems were encountered.

During the three-days of being on-site, the following activities were observed:

* Sampling train set-up and collections at each of the five locations (see page 4.7, Figure 4.2 of the QA Project Plan), with interviews with each location crew leader.

* Sample recovery representative of a (1) USEPA Method 23 Semi-Volatile Organic Compounds (2) USEPA Method 29, Multiple-Metals sampling train (3) USEPA Method 0011, Formaldehyde (3) USEPA Method 18, Gaseous Organic Compounds.

* Boiler plant operations

* SNRB operations

Details:

All of the five sampling locations were manned by a crew leader plus a helper and each location was equipped with 2-way FM radios for communications purposes. While observing each of the locations, a review of the field data sheets was made at several locations to assure that the data was being recorded at the time specified. We observed that the probes were marked and the ducts were being traversed according to the protocol. Each crew leader was knowledgeable of his job function and each indicated previous and extensive field experience.

Sample recovery was done in rooms designated specifically for this purpose and pedestrian traffic was restricted to sample recovery personnel. Care and caution to prevent external contamination of samples was evident by the diligence applied by each sample recovery person. It appeared that each sample recovery person was well-aware of potential contamination problems and each one exhibited extensive prior experience in sample recovery.

We observed that the sample recovery procedures were followed according to the protocol as specified in the QA Project Plan. Clean, "I-Chem" brand, glass bottles were used for all sample containers. Each sample bottle was labeled properly and a "Chain-of-Custody" form was initiated at this point in time.

During the second day, a problem in collection the gaseous organic sample by Tedlar bag method was encountered. This was due to the high negative pressure in the duct. Resolution of the problem was not made during the audit.

A walk-through the R.E. Burger plant's control room was made at intervals while the flue gas sampling was occurring to assure that the plant was performing at the nominal expected values. These values were compared to those found on page 4-5, Table 4-1, Unit 8 Operating Conditions and Permitted Deviations, in the QA Project Plan. We had observed that the EER Field Manager was in constant communication with the control room operators and his five sample location crew leaders. Thus, the flue gas sampling was conducted only while the boiler was in the optimal operating conditions.

There was a problem with excess moisture in the coal as it was being fed to the pulverizers. The excess moisture caused the feed lines to plug, resulting in an interruption of boiler operations. Flue gas sampling was stopped until the coal feeder problem was corrected and the boiler was back on line.

The Babcock & Wilcox SNRB control room is located next to the stack. The SNRB control room monitors the operations of the SNRB unit. A walk through the control room was made during the flue gas sample collection periods to assure that the unit was performing within the specified ranges as listed in Table 4-1 in the QA Project Plan. The EER field manager was in constant radio communication with the SNRB control room operators. This information was then communicated to the EER sample location crew leaders.

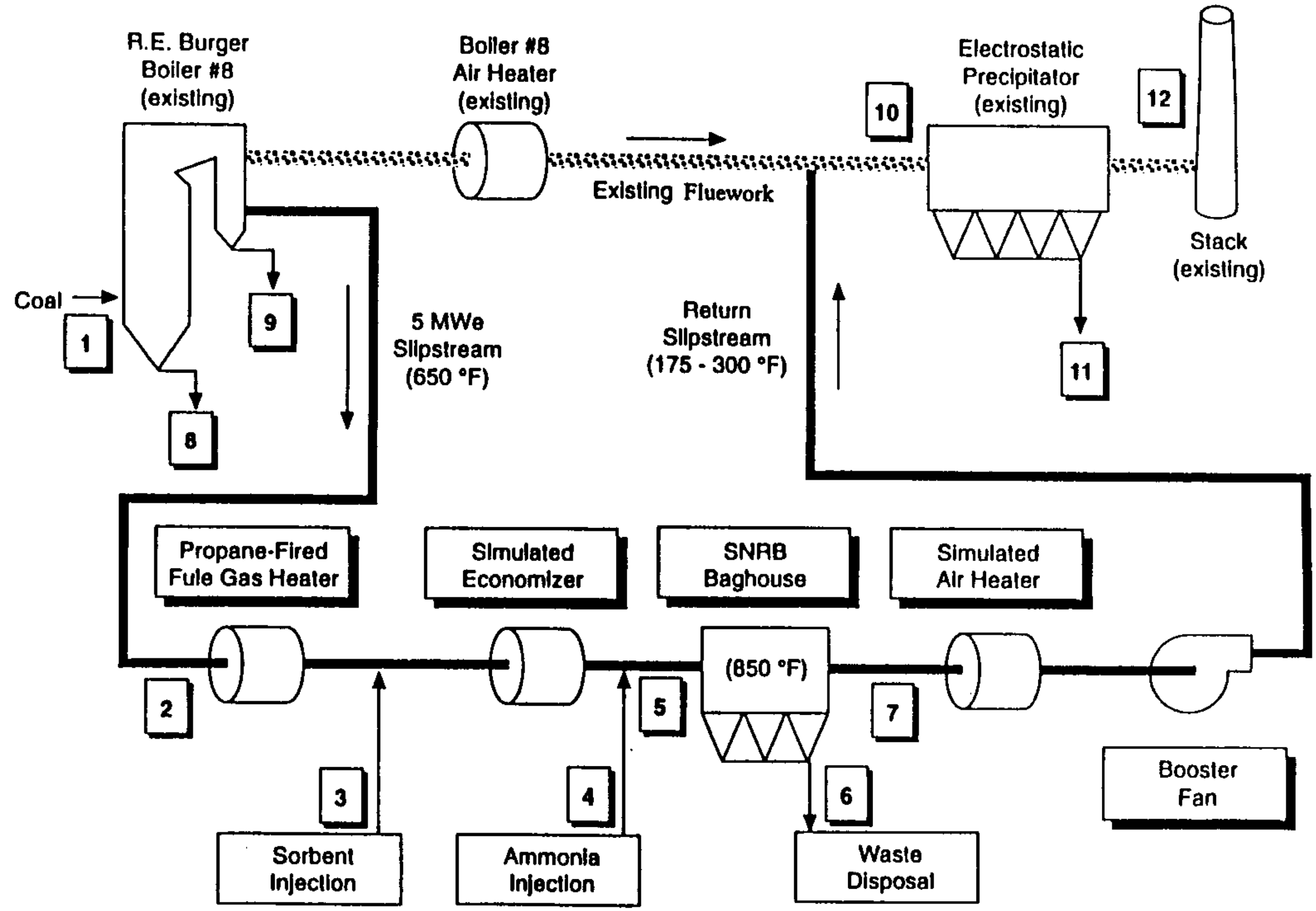


Figure 4-2. Sampling locations.

TABLE 4-1. UNIT 8 OPERATING CONDITIONS AND PERMITTED DEVIATION

Parameter	Nominal Expected Value	Allowable Range[a]
<u>Boiler operating conditions</u>		
Coal	Constant source, if possible	
Load, MW	150 or 156	135-158
Oxygen monitor readings, percent	3.0-5.0	2.9-5.3
Steam temperature at superheater outlet, F	1050	1000-1060
Steam temperature at reheater outlet, F	1000	950-1010
Steam pressure, psig	2050	2000-2075
Steam generation rate, lb/hr	1,100,000	$0.95\text{-}1.2 \times 10^6$
<u>Emissions</u>		
Stack opacity, percent	5-10	15[b]
Stack SO_2 (measured at SNRB inlet), ppm	2100-2500	Actual
Stack NO_x (measured at SNRB inlet), ppm	400-500	350-550
<u>SNRB operating conditions</u>		
Modules on line	5	5
Torn bags	None	None
Inlet SO_2 concentration, ppm	1950-2550	Actual
Inlet NO_x concentration, ppm	350-500	Actual
Sorbent feed rate, lb/hr	450-500	(B&W)
Ammonia injection rate, lb/hr	7.0-8.0	(B&W)
Ammonia atom.-air injection rate, lb/hr	200-225	(B&W)
Baghouse pressure drop, in. water	10-14	(B&W)
<u>SNRB Emissions</u>		
Outlet SO_2 concentration, ppm	350-1400	Actual
Outlet NO_x concentration, ppm	30-250	Actual
Outlet duct opacity, percent	<10	<15

(a) Where B&W is indicated, actual values are acceptable unless Babcock & Wilcox stops the test upon indication of improper SNRB system performance.

(b) Instantaneous opacity reading may exceed this value temporarily during sootblowing.